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REPORT

FINAL REPORT

Kingston Inner Harbour—Risk Assessment Refinement and Synthesis

Submitted to:
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Study Limitations

This document provides a refinement and synthesis of risk assessment information compiled for the Kingston Inner Harbour water lots. The report combines investigations and interpretations by multiple parties—including Golder Associates Ltd. (Golder)—both in terms of characterizing the spatial extent and magnitude of contamination and in characterizing the effects of contaminants to organisms. The objectives of this report are to provide an integration and overview of the collective technical findings, update previous interpretations based on feedback from Federal Contaminated Sites Action Plan (FCSAP) Expert Support departments, and render conclusions on overall risk for multiple management units within Kingston Inner Harbour.

The report includes data and information collected during investigations conducted by Golder Associates Ltd. (Golder) personnel and their subcontractors/subconsultants; these investigations have included supplemental sediment quality assessments, data gap assessments, source evaluations, coring studies, and targeted technical research in the field of aquatic health assessment, as described in this report. The report also includes compilations of environmental data by other parties, including the Royal Military College, Environmental Sciences Group (RMC-ESG). In evaluating the data, we have relied in good faith on information provided by the subcontractors/subconsultants and other site investigators. Quality assurance procedures were applied to improve data quality but these cannot guarantee accuracy of all data. For the purpose of this study, we assume that the information provided by others 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 others. Assessment has been made using the results of discrete chemical analyses and bioassays 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.

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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. With respect to regulatory compliance issues, regulatory statutes and the interpretation of regulatory statutes are subject to change. If new information is discovered during future work, including dredging, sediment boring, or other investigations, Golder should be requested to re-evaluate the conclusions of this report and to provide amendments, as required, prior to any reliance upon the information presented herein.

The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of Golder's report or other work products.

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ABBREVIATIONS

2LAET	second-lowest adverse effect threshold
AB	Anglin Bay (management unit)
ADAF	age-dependent adjustment factor
Ag	silver
APEC	area of potential environmental concern
As	arsenic
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	bioaccumulation factor
BHC	benzene hexachloride
BSAF	biota-sediment accumulation factor
BW	body weight
CCME	Canadian Council of Ministers of the Environment
CFB	Canadian Forces Base
COA	Canada-Ontario Decision-Making (Assessment) Framework
COPC	contaminant of potential concern
Cr	chromium
Cu	copper
CRSG	Cataraqui River Stakeholders Group
CSD	Contaminated Sites Division
CSM	conceptual site
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DNA	deoxyribonucleic acid
DO	dissolved oxygen
DQA	Detailed Quantitative Assessment (per COA Framework)
DQRA	detailed quantitative risk assessment
dry wt	dry weight
E	east
Eco-SSL	ecological soil screening level
EPC	exposure point concentration
EqP	equilibrium partitioning
ERA	ecological risk assessment
FCSAP	Federal Contaminated Sites Action Plan
HC	Health Canada
Hg	mercury
HHRA	human health risk assessment
HQ	hazard quotient
IC_X	Inhibition concentration causing x% reduction (in endpoint relative to control/reference)
IC_{20}	Inhibition concentration causing 20% reduction
IDW	inverse distance weighting

ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System (US EPA)
ISQG	Interim Sediment Quality Guideline
KIH	Kingston Inner Harbour
KOH	Kingston Outer Harbour
LAET	lowest adverse effect threshold
LEL	lowest effect level
LOAEL	lowest-observed adverse effect level
LOEC	lowest observed effect concentration
MATC	maximum acceptable toxicant concentration
MDL	method detection limit
N	north
N/A	not applicable
NEL	no-effect level
NOAA	National Oceanographic and Atmospheric Administration
NOAEL	no-observed adverse effect level
NOEC	no-observed-effect concentration
OM	Orchard Street Marsh (management unit)
OMOE	Ontario Ministry of Environment
PAH	polycyclic aromatic hydrocarbon
Pb	lead
PC	Parks Canada
PCB	polychlorinated biphenyl
PEL	Probable Effect Level
PQA	Preliminary Quantitative Assessment (per COA Framework)
PQRA	Preliminary Quantitative Risk Assessment
PSDDA	Puget Sound Dredge and Disposal Analysis
PSQG	Provincial Sediment Quality Guidelines
RAF	relative absorption factor
RC	Rowing Club (management unit)
RfD	reference dose
RFP	Request for Proposal
RIVM	Netherlands National Institute for Public Health and the Environment
RMC-ESG	Royal Military College, Environmental Sciences Group
RSL	Regional Screening Levels
SAR	Species at Risk
Sb	antimony
SEC	sediment effect concentration
SEL	Severe Effect Level
SeQO	sediment quality objective
SIR-300	sodium form chelating weak acid cation resin
SQG	sediment quality guideline
SQT	Sediment Quality Triad

TBT	tributyltin
TC	Transport Canada
TDI	tolerable daily intake
TEL	Threshold Effect Level
TIE	toxicity identification evaluation
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TRV	toxicity reference value
UCLM	upper confidence limit of mean
US EPA	United States Environmental Protection Agency
W	west
WDNR	Wisconsin Department of Natural Resources
WHO	World Health Organization
WQG	water quality guideline
WM	Woolen Mill (management unit)
Zn	zinc

1.0 INTRODUCTION

This document provides a refinement and synthesis of risk assessment information compiled for the Kingston Inner Harbour (KIH). It is being prepared in response to the Public Works and Government Services (PWGSC) Request for Proposal (RFP) No. EQ447-151193/A, and addresses the scope provided in the *Annex A: Statement of Work—Risk Assessment Refinement for the Kingston Inner Harbour, Transport Canada and Parks Canada Waterlot, Kingston, Ontario*, dated 26 September 2014.

Overall the last decade, a wealth of information has been collected in KIH, both in terms of characterizing the spatial extent and magnitude of contamination and in characterizing the effects of contaminants to organisms. Multiple rounds of field studies and desktop evaluations of risks to humans and aquatic life have been conducted. These studies have been reviewed at milestone reporting stages by the Federal Contaminated Sites Action Plan (FCSAP) Expert Support departments, which provide oversight of the technical competency of environmental investigations. Most of the investigations have followed the Canada-Ontario Decision-Making Framework for assessment of Great Lakes Contaminated Sediment (COA Framework; Environment Canada and Ontario Ministry of the Environment [OMOE] 2008) that uses an ecosystem approach to sediment assessment; this framework is intended to standardize the decision-making process while also being flexible enough to account for site specific considerations.

1.1 Objectives

The overall objective of the work is to refine and update risk assessment findings for the KIH, including results for water lots that are separately administered by Parks Canada and Transport Canada. The Parks Canada and Transport Canada water lots are located in adjacent portions of KIH between Belle Island and the LaSalle Causeway, and contamination from multiple historical sources has crossed water lot boundaries. Therefore, coordinated assessment of these lots under both federal custodians is preferred to piecemeal evaluation, and as such, Public Works and Government Services Canada (PWGSC) has acted as the overall coordinator of investigations for both sets of federal properties.

Due to the size of the study area and the number of environmental investigations conducted over the last decade, a diversity of risk assessment deliverables and data summaries has been prepared over time. For the purpose of guiding site management, results from recent environmental investigations have now been synthesized, including compilations of environmental data by the Royal Military College, Environmental Sciences Group (RMC-ESG) and by Golder Associates on behalf of PWGSC. RMC-ESG has prepared several chapters following the Canada-Ontario Decision-Making Framework, beginning with a synthesis of historical sources, and carrying through various levels of risk assessment toward an options analysis for forthcoming site management (RMC 2014). Concurrent with their efforts, additional investigations have been conducted on behalf of PWGSC on both the Transport Canada and Parks Canada properties; these investigations have included supplemental sediment quality assessments, data gap assessments, source evaluations, coring studies, and targeted technical research in the field of aquatic health assessment (e.g., toxicity reference value derivation, evaluation of causes of bottom fish deformities). The investigations led by RMC-ESG and Golder have been further augmented by several other environmental research studies, including collection of biota tissue chemistry, sediment toxicity, and other measurements of value to the risk synthesis.

In parallel with the environmental investigations, consultation with several stakeholders has occurred, with the purpose of summarizing the environmental condition of the Kingston Inner Harbour, providing advice on whether management actions are warranted, and investigating the potential for funding mechanisms such as FCSAP to implement environmental management recommendations. In the last decade, under the oversight of RMC-ESG, the City of Kingston joined with OMOE, CFB Kingston and Rideau Renewal Inc., and other stakeholders in creating the Cataraqui River Stakeholders Group (CRSG). Parks Canada, Transport Canada, and Environment Canada have also participated in the CRSG workshops and discussions; however, the technical representatives under the FCSAP process (Expert Support Departments including Department of Fisheries and Oceans, Environment Canada, and Health Canada) have not participated as CRSG members. Accordingly, one of the stated concerns of PWGSC, as reflected in the study objectives for this risk synthesis, is to ensure that all pertinent information is gathered and scrutinized by Expert Support prior to making decisions on preferred management alternatives. Accordingly, the custodial departments require a unified assessment for all KIH water lot parcels, incorporating technical feedback from Expert Support as appropriate and considering several risk pathways that overlap the water lot boundaries. Furthermore, the synthesis must include information from all organism types (benthic organisms, fish, birds, mammals, herptiles, and humans).

In response to these project needs, the components of this study included the following:

- Review and response to FCSAP Expert Support comments to the RMC-ESG (2014) report “Application of the Canada-Ontario Decision-making Framework for Contaminated Sediments in the Kingston Inner Harbour.” The purpose of our response was not to incorporate every edit to the document package, which remains the work product of RMC-ESG, but rather to address technical issues that substantively influence the numerical characterization of risk (e.g., calculations of hazard quotients [HQs], partitioning into management units) or that otherwise meaningfully influence the risk conclusions (i.e., in a manner that has implications for remedial options analysis).
- Incorporation of feedback from Expert Support comments on the Golder (2015) draft version of this report. Some additions, edits, and clarifications have been provided in this document version to address issues raised from Expert Support. A separate technical memorandum has also been prepared to document the specific responses to these questions. Appendix D includes the feedback from previous stages of Expert Support consultation on this project.
- Consolidation and refinement of risk assessment findings (i.e., risk characterization outcomes) from multiple investigations conducted to date. This document is intended to summarize findings from all investigators and risk pathways.
- Identification of risk-based benchmarks in sediment, where appropriate, to assist in remedial options analysis.
- Identification of zones of KIH sediment where multiple significant risks are present. By overlaying results for multiple constituents and pathways in a spatially explicit manner, zones are identified that have the greatest priority for risk management.
- Liaison with FCSAP Expert Support, both in terms of finalizing technical decision points for the risk assessment synthesis and for the communication of findings. Liaison with FCSAP expert support was conducted before and during the risk refinement stage, including during the finalization of the draft report.

The above objectives are satisfied by this deliverable, which summarizes the principal findings from the risk refinement process, including documentation of key assumptions. This document does not provide all of the raw data and processing details, many of which are contained in RMC-ESG (2014), Golder (2011, 2012, 2013a, 2013b, 2013c, 2014).

1.2 Historical Overview

An initial challenge in the implementation of the Canada-Ontario Decision-Making (COA) Framework was the piecemeal manner in which environmental investigations were completed. The multiple tiers of investigations, multiple federal custodians and stakeholders, and multiple groups providing interpretative reports, initially made it difficult to advance a clear, comprehensive, and systematic approach to risk management. Substantial effort was expended in investigating sediment-related risks in KIH over the last decade, including detailed tools such as laboratory toxicity testing, toxicity identification evaluation, tissue bioaccumulation assessment, and monitoring of bottom fish deformities. In addition, multiple rounds of feedback and recommendations have been provided through FCSAP Expert Support review, third party technical review, and stakeholder feedback (such as through the Cataraqui River Stakeholder Group[1]).

The main documents used to summarize the state of the KIH environment include:

- RMC-ESG publications related to their studies within KIH, which are organized in five chapters (I through V), culminating in the Chapter V report titled "An Options Analysis of Management Scenarios for the Kingston Inner Harbour." The most recent iteration of the RMC-ESG Application of the Canada-Ontario Decision-Making Framework for Contaminated Sediments in the Kingston Inner Harbour was dated February 2014 (RMC-ESG 2014).
- PWGSC sponsored a Preliminary Quantitative Assessment (PQA) and Detailed Quantitative Assessment (DQA) of KIH following the Canada-Ontario Framework for assessing risks under the FCSAP program (Golder 2011, 2012). These studies incorporated both technical results from RMC-ESG investigations but also included additional studies to address information gaps. The DQA was finalized in March 2012 following multiple rounds of site-specific investigation.
- Following the DQA, follow-up investigations for PWGSC were conducted in both the Parks Canada and Transport Canada water lots to address information gaps identified in the DQA. These studies, conducted primarily by Golder Associates Ltd., included a Sediment Gap Analysis for the Parks Canada property, a literature assessment of potential causes of bottom fish deformities in KIH, a review of potential sources of contaminants in the southwest portion of the Transport Canada water lot, and a refined sediment investigation in the southwest portion of the Transport Canada waterlot (including surface grabs and core profiling). Golder also provided a technical review of the RMC-ESG (2014) reporting package, intended to assist the remedial options analysis by the custodial departments.

[1] The Cataraqui River Stakeholders Group (CRSG) was formed in June 2006, and led by the Environmental Sciences Group of the Royal Military College of Canada (RMC-ESG). The CRSG includes participation of the City of Kingston, Rideau Renewal Inc., and regulatory agencies (e.g., Ontario Ministry of the Environment, Environment Canada, Transport Canada, Parks Canada, Fisheries and Oceans Canada, Department of National Defense). Note that FCSAP Expert Support members (from Health Canada, Environment Canada, DFO) are neither members of the CRSG nor key stakeholders, but rather provide technical advice to federal custodians.

- FCSAP Expert Support subsequently provided three sets of detailed technical comments (from Environment Canada, Health Canada, and Fisheries and Oceans Canada) that commented primarily on the RMC-ESG (2014) reporting package. These comments, received in June/July 2014, are distinct from the previous Expert Support comments on an earlier draft of the reporting package; the latter were responded to by RMC-ESG and are included in the RMC-ESG (2014) reporting package as Attachments.
- FCSAP Expert Support subsequently provided detailed technical comments (separately for each of Environment Canada, Health Canada, and Fisheries and Oceans Canada) that commented on the Golder (2015) draft risk synthesis reporting package. Consultation in 2015 also included a series of teleconferences with Expert Support and some follow-up technical communications (e.g., Health Canada reviewed and commented on draft human health risk calculations for two COPCs in August 2015). Appendix D documents the additional written comments received by Expert Support in this regard.

In recognition of the complex background summarized above, PWGSC has prudently adopted to consolidate and update the available information (including regulatory feedback) into a “risk assessment consolidation and refinement step.” The latter step, the results of which are summarized herein, draws together information from multiple adjacent water lots and synthesizes information and recommendations from multiple reporting rounds.

1.3 General Approach

Within each receptor group, FCSAP Expert Support has provided detailed commentary and recommendations for refinements. However, some general themes were identified that influenced the overall approach to the risk refinement, including:

- Synthesis of sediment chemistry to reflect current conditions—There was a recommendation to exclude data considered too old to reflect current surface sediment conditions, and to assess the representativeness of data collected near the timing of the sediment dredging near Emma Martin Park circa (2004-2005). Accordingly, the risk refinement rescreened the sediment data, to verify inclusion of all relevant PWGSC data including recent collections not included in the RMC-ESG documentation, and to exclude results that were considered either too dated or non-representative.
- Synthesis of fish tissue chemistry to reflect current conditions—There was a recommendation to exclude data considered too old to reflect current fish tissue concentrations. Accordingly, the risk refinement re-evaluated biota tissue chemistry to verify inclusion of all relevant PWGSC data.
- Definition of Areas of Potential Environmental Concern (APECs)—Several Expert Support comments related to the need to define more clearly the sediment management units, both in terms of the overall study area boundaries and the subunits within the overall study area. Accordingly, our risk refinement has provided an updated, clear, and consistent system for labelling and referencing sediment units (i.e., management units).
- Spatial averaging and characterization of effects in spatially explicit manner—several Expert Support comments emphasized the need to consider risk outcomes more clearly linked to subunits of KIH, particularly for wildlife (mammals/birds) and fish. Whereas the assessments have been spatially explicit in the benthic community assessment, the mobile receptors that cross waterlot boundaries require a refined assessment of the home ranges and habitat preferences of these organisms. In response, our risk refinement explicitly addressed the spatial scale of exposures; the home ranges of each receptor type (including human uses) were linked to the management units described above.

- Consider protectiveness of selected receptor species—Several Expert Support comments focused on the potential relevance of wildlife species not explicitly considered in the ERA. For example, muskrat and red wing blackbird were suggested as candidate species for an assessment of nearshore species, and the potential contribution of risks from Orchard Street marsh (via soil contact) was raised. In addition, risks to herptiles and endangered species were raised as uncertainties in the current ERA documentation. In response, the risk refinement has provided an evaluation of muskrats, insectivorous birds, and herptiles, subject to the constraints of the available data.

- Consider all risk pathways—Expert Support concluded that the RMC-ESG documentation (specifically Chapter V) prematurely emphasized certain risk pathways, while excluding others, in summarizing the overall risk of sediment related contamination. For example, the benthic community responses and morphological abnormalities in fish were not accounted for in the development of site-specific sediment quality objectives. In response, the risk refinement has carried all ecological receptors through to the overall assessment, such that risks can be compared across receptor types.

- Exposure Point Concentrations (EPCs)—Expert Support identified that the Golder (2015) risk synthesis used different statistical metrics to derive sediment EPCs for sediment using the Inverse Distance Weighting (IDW) approach. For example, EPCs for the fish health assessment were calculated using 75th percentiles, whereas calculations for the wildlife assessment used 90th percentiles, and the herptile assessment used 95th percentiles. In response, the revised risk refinement has provided rationale (based on the level of conservatism required in the face on uncertainty) for the metric selected for each receptor group.

In implementing the FCSAP Expert Support recommendations, it was necessary to focus on those parameters, assumptions, and data processing decisions that most significantly influenced the outcome of the risk assessment. Our scope did not entail a revision or recalculation of the entire risk assessment. Instead, it relied in large part on the large repository of information (including models, parameters, and quantitative analyses) from existing documents. For some pathways, it was necessary to revise the models to address specific concerns raised by FCSAP Expert Support. For example, Health Canada noted that as "some comments are significant in nature and thus may impact the interpretation of the HHRA and any decisions stemming from it." In such cases, Expert Support groups were contacted, technical approaches discussed, and the methods revised to reflect those discussions.

1.4 Constraints/Limitations

This report is subject to the terms and assumptions described in the general limitations section provided at the beginning of this document. A specific limitation to the spatial depiction of risks is that the results do not account for changes over time, under either a natural recovery scenario or under physical intervention (e.g., shoreline development, dredging). Multiple Expert Support comments commented on the need to better understand sediment stability prior to remedial option evaluation, and although Golder concurs with these comments, it is not possible to assess the influence of sediment transport and redistribution within the scope of this study. Depending on the outcome of the remedial options evaluation (including input from stakeholders) it may be necessary to model additional exposure scenarios that would apply to a future redeveloped condition of KIH.

The scope of our study excludes the following components:

- New data collections since 2014—we relied on information in hand during the period of preparation of the draft synthesis report, documenting significant uncertainties as appropriate.

- RMC-ESG Deliverables—Expert Support Comments relating to the structure or content of the RMC-ESG deliverables were not part of the study scope. Instead, the risk refinement emphasized key issues identified by Expert Support (i.e., not a comprehensive reanalysis of the full quantitative risk assessment).
- Detailed documentation of raw data processing—Unlike a DQRA, this risk synthesis report does not provide documentation of all data processing steps used to convert raw data (e.g., individual concentration data) from primary data sources to summary exposure metrics. As such, readers interested in those details must consult the source reports and associated appendices. Golder has provided numerous references to the original sources of the data, focussing on the parameters and model assumptions that have the greatest bearing on risk estimates.
- Risk management decisions or stakeholder input—Following the COA Framework, we have applied a systematic approach to screening, identification of information gaps, and refinement of preliminary risk estimates. Although input from stakeholders, including the CRSG, may ultimately influence the prioritization of risk pathways, receptors, and preferred remedial tools, this document is restricted to a science-based evaluation of risks.

2.0 SITE CONTEXT

2.1 Study Area Definitions

Sediments in the Kingston Inner Harbour fall under the jurisdiction of numerous private and public parties. The formal legal boundaries of the Transport Canada and Parks Canada water lots are shown in **Figure 1**. Due to the number and complexity of water lot designations, definitions of terms are needed to provide clarity and consistency.

The first definition of interest relates to the spatial domain of the entire Kingston Inner Harbour (KIH), a study area that includes both the Transport Canada and Parks Canada water lots and other adjacent water lots. In terms of the formal legal definition, KIH is bounded to the north by Highway 401, which crosses the Rideau Canal; the northern portion of the study area falls under the jurisdiction of Parks Canada. The full extent of the Parks Canada section of KIH also includes the Great Cataraqui Marsh, as well as other sediments to the north of the mapped region shown in **Figure 1**. Adjacent to Belle Island, the Great Cataraqui River flows into sediment units that fall primarily under the jurisdiction of Transport Canada (**Figure 1**). The Transport Canada jurisdiction includes several parcels (defined as Part 1 through Part 5). The downstream boundary of KIH falls near the LaSalle Causeway, south of which the sediment bed lies in an area defined as the Kingston Outer Harbour (KOH). The KOH water lot is being separately managed by Transport Canada.

Whereas the legal definition of KIH includes a significant area of sediment north of Belle Island, a more practical definition of the KIH study area focusses on the subset of sediments for which significant historical sediment contamination is present. That zone of interest consists of the region south of Belle Island and north of the LaSalle Causeway. The area north of Belle Island, although still a part of the legal definition of KIH, is a relatively uncontaminated zone; both Golder (2011, 2012a) and RMC-ESG (2014) have independently concluded that most areas north of Belle Island serve as a local reference area (i.e., Upstream Reference Zone) against which the more industrialized portion of KIH can be compared.

Rather than use complex terminology to describe the areas of greatest risk potential, we have adopted the following nomenclature for use in this report:

- **The Site—**the area defined by strict legal boundaries of the Transport Canada and Parks Canada water lots (inclusive of sediments from Highway 401 to LaSalle Causeway).
- **KIH—**the section of the Great Cataraqui River that is downstream of Belle Island but upstream of the LaSalle Causeway. This zone includes sediment parcels under the jurisdiction of Transport Canada (5 parcels), Parks Canada (1 parcel), Department of National Defence (1 parcel), and a private lot near the Woolen Mill (1 parcel). KIH also includes some small strips of wetted area adjacent to the Orchard Street brownfield area and Douglas Fluhrer Park, which are upgradient of the Transport Canada western property boundary (**Figure 1**).
- **Zone—**the totality of the aquatic environment (bed sediments, overlying water, particulate matter, biota, and riparian area) over a defined spatial unit.
- **Upstream Reference Zone—**the section of the Cataraqui River downstream of Highway 401 but upstream of Belle Island. Although this area part of the legal definition of KIH, the upstream reference zone is not currently being considered for active risk management. Instead, the Upstream Reference Zone has provided locations for reference sampling (e.g., sediment, fish, and benthic community) that provide a regional background characterization against which KIH environmental quality can be assessed.

- **Transport Canada Zone—**the combination of water lots TC Part 1 through TC Part 5, all of which occur within KIH.
- **Parks Canada Zone—**specific to this project, the Parks Canada zone is the subset of KIH sediment located to the west (downstream) of Belle Island. The formal legal descriptor for this parcel is Parks Canada Part 1 (Plan 13R – 13481). In this context, the zone excludes the Upstream Reference Zone, and instead refers only to the area south of the Former Belle Landfill.
- **Management Units—**subsections of KIH that have been identified based on profiles of sediment quality, proximity to upgradient sources, and riparian features. The configuration of the management units is depicted in **Figure 2**. Individual management units are detailed further in Section 2.6.
- **Western KIH—**the western half of KIH, which excludes the sediments within management units TC-E and PC-N. Western KIH contains the sediments of greatest environmental concern, and includes areas of sediment for which the DQA (Golder 2012) indicated ecological risks that may warrant active management. Both Golder (2011, 2012a) and RMC-ESG (2014) have independently concluded that the Western KIH domain contains the sediments of greatest priority for environmental management, whereas TC-E sediments do not warrant consideration for physical intervention due to lower risk.
- **APEC—**this term is not used in this report except in reference to the RMC-ESG (2014) assessment. The spatial boundaries for this unit were not clearly specified, and Expert Support indicated a preference for multiple zones based on differences in contamination profiles (and receptor exposures to sediment) across the KIH.

Due to the size of the site and complexities of adjacent land uses (including parcels owned by the City of Kingston, multiple federal government agencies, private owners, and corporations) the overall management of KIH sediments is a complex problem with interrelated contamination issues, and numerous historical and current operable pathways for contamination. A summary of adjacent land uses and areas of potential environmental concern is provided in Golder (2009). Chapter 1 of RMC (2014) also provides an excellent summary of the history and legacy contamination sources within KIH.

The Upstream Reference Zone (or reference area) referenced in this report refers to the Parks Canada water lot areas north of Belle Island. Additional locations such as the unnamed creek leading form the Kingscourt outfall, Orchard Street Marsh, and the various historical industrial sites and parks neighbouring KIH are included in **Figure 1**.

2.2 Upland Sources of Contamination

Upland sources of the main contaminant groups to pose a risk to environmental health include:

- **Inorganic metals (particularly chromium, lead, arsenic, copper, and zinc)—**These contaminants are associated primarily with historical industrial activities along the western shoreline of KIH, such as the Davis Tannery, Frontenac Lead Smelter, and the Woolen Mill, although other urban sources including storm water discharges have contributed to contamination. Source control actions and targeted sediment removals have occurred along the western shoreline, but legacy contamination remains in the waterlot (**Figures 3–10**). Elevated concentrations of copper relative to sediment concentrations present within KIH were observed in the northern portion of Anglin Bay in close proximity to the MetalCraft Marine shipyard. Copper is a common constituent of antifouling paints used on boat hulls. Elevated concentrations of copper observed may be related to current and/or historical ship building/maintenance activities in the area.

- **Mercury—**Mercury is present in organism tissues mainly in the organic form (methylmercury), and is associated with discharges from industries, including historical contamination from the vicinity of the Woolen Mill (**Figure 8**). Localized dredging (and upland source control) have reduced the mercury contamination near this source area, although redistribution of mercury-contaminated sediment has occurred through most of the shoreline management units of Western KIH.

- **Nutrients—**The entire Lower Cataraqui River, including the Upstream Reference Zone, contains elevated nutrient conditions, and therefore some sediment chemistry parameters (e.g., organic carbon, nitrogen, and phosphorus) are elevated. The KIH is a eutrophic environment.

- **Organotins—**Spatial profiling of tributyltin (TBT) in 2010 and 2011 (Golder 2011; 2012) indicated that exceedances of screening criteria for TBT were only observed within portions of Anglin Bay, and not in remaining areas of KIH. This spatial distribution is expected due to the close association of TBT contamination with the historical usage of TBT as an antifoulant on vessel hulls. Although TBT is now a restricted substance in antifouling paints, residual contamination of harbours can occur in areas of extensive ship moorage, particularly where scraping or blasting of ship hulls is conducted near open water.

- **Polychlorinated biphenyls (PCBs)—**Contamination of sediments by PCBs have been documented in the Parks Canada waterlot of KIH, and was historically associated with leachate from the former Belle Landfill. Golder (2011) provides a review of pathways for this portion of the harbour, focussing on pathways to the Parks Canada zone. However, recent sediment quality assessments have also documented widespread sediment PCB contamination (Golder 2012, 2014), and the pattern over much of KIH is inconsistent with landfill leachate as the primary source **(Figure 11)**. In particular, the accumulation of elevated PCBs (above 0.5 mg/kg dw total PCB) in much of the central and south portions of KIH, without a contiguous connection to Belle Island, indicates that other sources dominate PCB accumulate at the harbour-wide level. Two former demolition/scrap yard properties may have also contributed to the PCBs found in the KIH sediment (MacLatchy 2013, pers. comm.). Poor PCB handling practices may have led to the discharge of PCBs through the storm sewer system from the Kingscourt outfall and in the vicinity of Douglas Fluhrer Park.

- **Polycyclic aromatic hydrocarbons (PAHs)—**Sediment PAH concentrations observed within KIH in the vicinity of Anglin Bay and the Douglas Fluhrer Park area are likely the result of historical contamination from a former rail yard and coal gasification plant (Golder 2013b). Although the overall contribution of sediment PAHs from the rail yard area is unknown, the spatial extent of contamination **(Figure 12)**, PAH composition, and type of industrial activity all suggest that rail yard activities played a significant role in contaminating the adjacent water lots of KIH. Within Anglin Bay, migration of PAHs from the large deposits of weathered coal tar historically transported via storm sewers are also expected to be responsible for the PAH concentrations found in nearby sediments. These historical contributions are expected to represent the bulk of the observed PAH contamination, with ongoing sources (i.e., storm water discharges, vessel traffic, hydrocarbon spills) representing only a minor component.

2.3 Data Sources

The RMC-ESG (2014) deliverable package provides an excellent summary of the chemistry data used by RMC-ESG in their application of the COA Framework. However, in response to FCSAP Expert Support comments, the underlying data sets have been revised, either to update with additional data not available to RMC-ESG at the time of their compilation, or to remove data points that are no longer applicable to the characterization of surface sediment quality (e.g., too dated or representing areas that have subsequently been dredged). The vast majority of data points were included in RMC-ESG (2014); therefore, this section summarizes the refinement of data sources used in the exposure assessment for the risk refinement.

Sediment Quality

Data from sample collections prior to 2001 were eliminated from the data set. Although the choice of 2001 as a cut-off year is somewhat arbitrary, the inclusion of data from the last 15 years reflects the low energy environment in Western KIH. Although small scale changes in near-surface sediment contamination occur through localized sedimentation and sediment redistribution over time, these physical processes are offset by bioturbation of the sediment, in which biological mixing of vertical layers diminishes the effect of vertical stratification. Furthermore, the uncertainty inherent in the use of post-2001 data is offset by the improved spatial profiling of some management areas made possible by the greater sample size and sampling density (particularly in the vicinity of the rowing club). Finally, even if some constituents have been buried (or eroded) since 2001 at specific sampling points, those constituents would likely remain in close proximity to the sampled area and would retain relevance to the area-weighted concentration within each management zone. In response to a request from FCSAP Expert Support, the retained data were sorted into categories reflecting the timing of collections: (a) 2010 to present; (b) 2006 to 2009; and (c) 2005 and previous. Different symbols have been used in the spatial distribution plots (**Figures 3–12**) to distinguish these groups of samples.

The retained data are summarized in the following reports:

- Derry et al. 2003. *PCB Source Trackdown in the Cataraqui River: 2001 Findings*. Technical Memorandum;
- Benoit and Dove 2006. *Polychlorinated Biphenyl Source Trackdown in the Cataraqui River—Results of the 2002 and 2003 Monitoring Programs*;
- Tinney 2006. *Site Investigation and Ecological Risk Assessment of Kingston Inner Harbour* (Master's Thesis);
- Benoit and Burniston 2010. *Cataraqui River Project Trackdown: Follow-Up Study on Success of Remediation Efforts in the Cataraqui River 2006*;
- Golder 2011. *Implementation of the Canada-Ontario Decision-Making Framework for Assessment of Great Lakes Contaminated Sediment—Kingston Inner Harbour, Framework Steps 4 and 5 (PQRA)*;
- Golder 2012a. *Implementation of the Canada-Ontario Decision-Making Framework for Assessment of Great Lakes Contaminated Sediment Kingston Inner Harbour: Framework Step 6 (Detailed Quantitative Assessment)*;
- Golder 2013. *Parks Canada Water Lot Sediment Quality Update*. Kingston Inner Harbour, Kingston, Ontario;

- RMC-ESG 2014. *Application of the Canada-Ontario Decision-Making Framework for Contaminated Sediments in the Kingston Inner Harbour*; and
- Golder 2014. *Transport Canada Waterlot Sediment Investigation—2013*. Kingston Inner Harbour, Kingston, Ontario.

Surface Water

All surface water data were obtained from the following source:

- RMC-ESG 2014. Application of the Canada-Ontario Decision-Making Framework for Contaminated Sediments in the Kingston Inner Harbour.

Fish Tissue

Two substantive programs of fish bioaccumulation were used to support the fish health assessment and the human health assessment of the fish ingestion pathway:

- RMC-ESG 2014. *Application of the Canada-Ontario Decision-Making Framework for Contaminated Sediments in the Kingston Inner Harbour*; and
- Golder 2011. *Implementation of the Canada-Ontario Decision-Making Framework for Assessment of Great Lakes Contaminated Sediment—Kingston Inner Harbour, Framework Steps 4 and 5 (PQRA)*.

2.4 Environmental Concentrations

2.4.1 Sediment Chemistry

Figures 3 to 12 provide spatial depictions of surface sediment (0–0.15 m) chemistry distributions for the constituents that screened through to the DQA. The concentration data are dominated by results from 2003 to 2013, with the exception of the area adjacent to the Woolen Mill and Rowing Club. For the latter, slightly older data from 2001 (from non-dredged areas) are required to provide adequate spatial characterization in this area. Sediment chemistry results were screened to exclude any areas dredged in 2005 in the vicinity of the rowing club. Sediment concentration surfaces were created using an ArcGIS Version 10.3.1 inverse-distance weighting (IDW) procedure. The IDW interpolation method considers the concentration values of the sample points and the distance separating them from each point (or cell). Sample points closer to the cell have a greater influence on the cell's estimated concentration than sample points that are further away. This approach, when used with sufficient resolution of data, provides a more reliable basis for calculation of weighted sediment exposure point concentrations (EPCs) relative to use of simple averaging within each management units or use of Theissen polygons[2].

The contaminants shown in **Figures 3 to 12** emphasized arsenic, chromium, PAHs, and, PCBs, which are primary sediment COPCs identified for the Site (Golder 2011, RMC-ESG 2014), but also included other constituents that have been routinely measured in KIH sediment (mercury, antimony, copper, lead, and zinc). The contaminant distributions in the Figures have been assigned to colour categories based on increasing SQG thresholds identified from the literature, including the federal (CCME) and provincial (OMOE) sediment quality guidelines. Screening

[2] Thiessen polygons are a special case of IDW interpolation method, in which only the nearest station is used for interpolating the data.

benchmarks considered in the categorization of data included other jurisdictions, both to fill gaps for some COPCs and to provide a range of concentration benchmarks:

- Wisconsin Department of Natural Resources (WDNR 2003)—Consensus-Based Sediment Quality Guidelines;
- Buchman (2008)—NOAA Sediment Quality Reference Tables (SQuiRT);
- Persaud et al. (1993) & OMOE (2008)—Ontario Ministry of the Environment sediment quality guidelines, including No Effect Level (NEL), Low Effect Level (LEL), and Severe Effect Level (SEL); and
- Michelsen (2003)—Washington Department of Ecology recommended SQGs for freshwater sediments, including Lowest Adverse Effect Level (LAET) and Second Lowest Adverse Effect Level (2LAET).

In addition to the above benchmarks, the exposure benchmarks for PAHs and PCBs developed by Golder (2013b) for potential risk of increased bullhead lesion prevalence have also been incorporated in the figures.

The plotting of concentration distributions (and associated colour coding) was not intended to provide a quantitative indication of risk, as the generic SQGs do not reflect site-specific considerations that mediate the bioavailability and toxicity of COPCs. Rather, the purpose was to convey broad spatial trends in the exposure distributions, and to provide context for the magnitude of concentrations through comparison to conservative benchmarks for aquatic health. This approach also facilitated the identification of data outliers (e.g., anomalously high concentrations in the Upstream Reference Zone, which were subsequently removed from the data set to avoid bias in the calculation of mean background concentrations).

For some COPCs, the density of data was not sufficient to support IDW smoothing across all areas, particularly for the eastern KIH and the Upstream Reference Zone. For example, antimony and mercury sediment concentrations in TC-E and PC-N (**Figures 3 and 8**) were not smoothed using IDW.

2.4.2 Water Chemistry

ESG (2014) concluded that surface water quality in the Inner Harbour generally meets the Ontario Provincial Water Quality Objectives, and that water quality is “generally good with respect to provincial and federal guidelines”. This conclusion was also reached by Malroz (2003). Based on this information, the aquatic and wildlife risk refinements focused on sediment and tissue-based measures of exposure, rather than water quality parameters.

For the human health risk assessment (HHRA), the surface water quality data presented in RMC-ESG (2014) were included in the quantification of the total ingestion pathway. Although concentrations of water-borne COPCs were low, the process of HHRA considers combined inputs from all pathways even when most exposure is driven by a single abiotic medium or exposure pathway. Locations of surface water collections in KIH are provided in **Figure 13**. These data provided robust estimates of water-based exposure in the northern portion of KIH and the Upstream reference Zone. For the management units in the southern portion of KIH, estimation of water exposures required extrapolation of results from adjacent sampling areas; this uncertainty is considered acceptably low given the relatively minor contribution of water-borne COPC exposure to total uptake.

2.4.3 Tissue Chemistry

For the ecological and human health assessments, the concentration summaries of fish tissue bioaccumulation data presented in ESG (2014) were used. The exposure point calculations considered results of recent fish tissue sampling by RMC-ESG and Golder, plus older studies documented in the literature.

The RMC-ESG (2014) study emphasized a combination of historical literature compilations for KIH and a reference site (from Scheider 2009 and Benoit and Dove 2006) and a recent program of field collections managed by RMC-ESG. The latter entailed collections of brown bullhead, yellow perch, and northern pike in autumn 2009, both within KIH and at a reference site located approximately 2 km up-river, adjacent to the Great Cataraqui Marsh. The data from these programs are detailed and summarized in Appendix D of RMC-ESG (2014), and the positions of sampling locations from these programs are summarized in Map III-7 of RMC-ESG (2014). Figure 16 of this report also shows the locations from these programs, including collections since 2009 for both sportfish and juvenile fish. The associated data within KIH provide a strong representation of the Parks Canada zone and the northern part of the Transport Canada zone. There is also strong representation of the Upstream Reference Zone, with fish tissue results available for multiple species, locations, and collection events for fish collected upstream of Belle Island.

The Golder (2011) program included both whole body analysis of small fish specimens (for ecological risk assessment) and fillet analysis of large recreational fish species (for human health assessment). These data were collected in the central and southern parts of the Transport Canada Zone, and were intended to complement the RMC-ESG (2014) evaluation.

2.5 Preliminary COPC Screening

RMC-ESG (2014) provides a detailed discussion of screening of sediment chemistry data, including comparison to guidelines, and comparisons of concentrations at reference locations to those observed in KIH (i.e., statistical analysis to determine if the mean of contaminant levels in KIH are significantly higher than the mean at reference sites).

Inclusion of the recent Golder (Golder 2011, 2012, 2013b, 2014) field sampling results warranted additional screening of sediment chemistry. This was necessary due in part to the sampling of KIH sediments in areas that had not been well characterized in previous sampling events, and in part because the list of COPCs was recently expanded to include metals and organics not evaluated by RMC-ESG (2014). For this purpose, sediment chemistry data were compared to both the Provincial Sediment Quality Guidelines (PSQG) for the protection and management of aquatic sediment (Ontario Ministry of Environment 2008; Persaud et al. 1993) and the Canadian Council of Ministers of the Environment (CCME) SQGs for the protection of aquatic life (CCME 1999). The PSQGs contain two sets of guidelines reflecting different levels of protection. The lower sediment values (the Lowest Effect Level, or LEL) represent concentrations that can be tolerated by the majority of sediment-dwelling organisms, whereas the higher guideline values (the severe effects level or SEL) represent concentrations likely to affect the health of sediment-dwelling organisms. Similar levels of protection (as expressed in the guideline narratives) are represented by the CCME interim sediment quality guideline (ISQG) and probable effects level (PEL), respectively. For parameters requiring calculation of total concentrations (e.g., total PCBs, total PAHs) an estimated value of one-half the limit of detection was used for individual concentration values below the method detection limit. The upper thresholds for reference sediment concentrations were determined by adding 20% to reference sediment concentrations (EC and OMOE 2008).

Following the COA Framework, analytes identified as meeting both of the following criteria were designated as COPCs in sediment:

- At least one station in the KIH exceeded the maximum concentration observed for that analyte at reference stations; and

- At least one station exceeded the lower-bound sediment quality guideline (CCME ISQG or OMOE LEL), or has the potential to biomagnify.

For some non-biomagnifying substances, sediment quality criteria were lacking. In these cases, analytes were identified as COPCs if the maximum concentration in exposed sediments was greater than three times the reference concentration (or corresponding analytical detection limit if non-detected).

The following subsections describe the screening results and COPC selection by analyte group.

2.5.1 Pesticides and Herbicides

A broad scan of pesticides and herbicides was conducted for a subset of sediments collected in 2010. No detectable concentrations (greater than the MDL) were observed in samples selected for analysis of pesticides and herbicides. In most cases the detection limit was 0.05 mg/kg dw or lower (i.e., <50 µg/kg dw). The groups of pesticides/herbicides evaluated included: aldrin, BHC compounds (3 analytes), chlordane compounds (3 analytes), DDD/DDE/DDT and related substances (10 analytes), dieldrin, endosulfan compounds (4 analytes), endrin compounds (3 analytes), heptachlor, heptachlor epoxide, hexachlorobenzene, lindane, methoxychlor, mirex, octachlorostyrene, and toxaphene. Although detection limits were not sufficiently low to definitively exclude substances such as toxaphene or DDD/DDE/DDT, the 100% non-detection frequency observed in the 2010 sampling was consistent with other results for samples analysed for pesticides and herbicides collected within the KIH from 2003 to 2013 (excluding areas dredged in 2005 in the vicinity of the rowing club). On this basis, pesticides and herbicides were excluded from further evaluation.

2.5.2 Substrate and Nutrient Characteristics

Although not treated as potential toxicants related to local KIH contamination sources, several sediment quality characteristics (percent fines, total organic carbon, nitrogen as Total Kjeldahl Nitrogen [TKN], total phosphorus, porewater ammonia, and sulphide) were examined as part of previous sampling programs conducted by Golder (2011, 2012, 2013b, 2014). These characteristics can be important for modifying the bioavailability and toxicity of sediment contaminants, or for influencing benthic community structure through eutrophication. The sediment analytical data indicated that reference stations in the Upstream Reference Zone were generally appropriate for matching the physical characteristics of test sediments from the sampling programs.

The degree of nutrient enrichment (as indicated by the TKN parameter) was similar in both KIH and the reference areas (reference stations bounded the range of TKN observed in exposed areas). Although it is possible that small-scale variations in TKN (or other nutrient parameters) may influence the biological and/or toxicological responses in KIH, the relatively flat gradient observed over the entire study area (i.e., most stations within a factor of 2 of each other) indicated that standardization of biological data to TKN would not significantly affect the results (Golder 2011). Total phosphorus concentrations also exhibited weak spatial gradients, with the vast majority of KIH stations intermediate between the LEL and SEL (Persaud et al. 1993). Similarly, TOC concentrations in KIH were typical of the conditions expected for the habitats sampled (Golder 2011, 2012a). Although the 10% TOC concentration has been identified as a SEL by Persaud et al. (1993) and OMOE (2008), this threshold was not considered to be biologically relevant to a nutrient enriched water body for which reference levels of TOC already exceed 10% (i.e., for most of the Upstream Reference Zone, as well as the eastern portion of KIH; Golder 2011).

2.5.3 Metals

The screening procedures described above identified the following sediment metals/metalloids as primary COPCs: arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. Mercury was carried forward in the PQRA on the basis of both sediment concentrations relative to guidelines and potential risk related to biomagnification (i.e., conversion to the methylated form of mercury, and subsequent accumulation in organism tissues). All metals found to exceed lower-bound SQGs were also observed to exceed 20% above reference concentrations at one or more stations.

In addition to the primary COPCs identified for the Site (Golder 2011, RMC-ESG 2014), four metals/metalloids (antimony, calcium, iron, and silver) were identified as secondary contaminants, indicating that there were no CCME or Ontario provincial guidelines for these analytes, but that concentrations were elevated relative to reference concentrations in portions of KIH:

- **Antimony—**Little is known regarding the sediment toxicity of antimony; however, concentrations of antimony in most of southern KIH exceeded the Washington Department of Ecology Lowest Adverse Effect Levels (Michelsen 2003). Antimony concentrations in exposed sediments were heterogeneous, with no single point source suggested by the spatial distribution (**Figure 3**).
- **Calcium—**As a macronutrient, calcium is not expected to be directly toxic, although it may be correlated with other macronutrients (including phosphorous and nitrogen) that may exert an indirect influence via eutrophication. Calcium concentrations were elevated by up to 5-fold relative to reference conditions (Golder 2011).
- **Iron—**Gradients in the spatial distribution of iron were fairly weak (Golder 2011). With the exception of a few samples near the mouth of the creek draining Orchard Street Marsh, iron concentrations were generally close to background levels within KIH, or were marginally elevated above background.
- **Silver —**Spatial gradients for silver were stronger than for other secondary COPCs, and were indicative of increased contamination along the western shoreline of KIH. Despite the lack of CCME and Ontario SQGs for silver, several stations within the KIH exceed the Lowest Adverse Effect Threshold (LAET) of 0.545 mg/kg from Washington Department of Ecology (Michelsen 2003). Furthermore, silver is often used as a tracer compound for the environmental fingerprinting of domestic and municipal wastewater discharge. The environmental distribution of silver in sediment along the western shoreline is suggestive of influence from the combined sewer overflows (CSOs) and other discharges along the shoreline.

2.5.4 Organic Contaminants

Concentrations of PCBs (Aroclor 1254, Aroclor 1260, and total PCBs) and PAHs (individual PAH compounds and as total PAHs) were identified as COPCs both on the basis of comparison to reference (i.e., greater than 20% above reference concentrations) and based on exceedance of lower-end SQGs at KIH stations. As PCBs (particularly the high molecular weight mixtures observed in KIH sediments) are also a potential concern with respect to biomagnification, these chemical groups were carried forward as COPCs.

Organotins were measured in a subset of sediment samples collected in 2010 (Golder 2011). Tributyltin (TBT) is the compound of greatest interest for environmental health, as it has been shown to elicit growth and reproductive effects in multiple invertebrate taxa. It was not possible to conduct screening to reference (no data available) or to Canadian SQGs (not currently available for sediment). However, Washington State, as part of the Puget Sound

Dredge and Disposal Analysis (PSDDA) program, has promulgated a sediment guideline for TBT (0.073 mg/kg dry weight TBT; Michelsen et al. 1996). On the basis of the exceedance of this value in Kingston Marina (i.e., maximum measurement of 0.210 mg/kg was approximately three times the PSDDA guideline), TBT was retained as a COPC.

2.5.5 COPCs for Human Health

The identification of sediment COPCs for human health pathways is more complicated than for aquatic life, in part because the Canadian (i.e., Canadian Council of Ministers of the Environment [CCME] and Health Canada) and Ontario (i.e., Ontario Ministry of the Environment [OMOE]) environmental quality guidelines and standards were not developed specifically for protection of human health. FCSAP Expert Support, through Health Canada, also raised a number of specific technical issues related to the screening of contaminants in the human health risk assessment. Accordingly, a refined screening approach was used to determine the contaminants of potential concern for human health, and was applied separately to each of the relevant media (sediment, surface water, fish tissue).

The details of the screening procedure are presented in Section 7, and correspond to three tiers of screening:

- Comparison of measured concentrations to health-based guidelines and standards and background sediment concentrations;
- Elimination of substances that lack health-based guidelines but are inert or have very low toxicological hazard, where applicable; and
- Comparison of measured concentrations to reference area concentrations, where applicable, with the 95% UCLM used to represent KIH sediment concentrations and the 95th percentile concentration used to represent reference conditions.

2.5.6 Summary of Sediment COPCs

Based on integration of historical and updated sediment screening steps following the COA Framework, the following decisions were made for preliminary COPC selection. The identification of a substance as a COPC does not imply evidence for adverse effects or health risk, but rather that the substance must be carried forward for evaluation in the risk refinement.

Table 1: COPCs Identified for the Refinement of the KIH Human Health and Ecological Risk Assessments

Analyte	COPCs for Ecological Risk Assessment	COPCs for Human Health Risk Assessment[4]
Metals/Metalloids		
Aluminum	No	Yes
Antimony	Yes	Yes
Arsenic	Yes	Yes
Cadmium	Yes	No
Chromium	Yes	Yes[2]
Cobalt	No	Yes
Copper	Yes	No
Iron	Yes	No
Lead	Yes	Yes
Manganese	No	Yes
Mercury	Yes	Yes
Nickel	Yes	No
Silver	Yes	No
Vanadium	No	Yes
Zinc	Yes	No
Other trace metals	No	No
Organics		
DDT	No	No
Other pesticides	No	No
Organotins (Tributyltin)[1]	Yes	No
PAHs	Yes	Yes[3]
Total PCBs	Yes	Yes
Nutrients		
Calcium	Yes	No
Nitrogen	Yes	No
Phosphorus	Yes	No
TOC	Yes	No

1. Tributyltin was identified as a COPC on the basis of comparison to sediment quality guidelines from Washington State (PSDDA) rather than reference screening.
2. Trivalent chromium only.
3. Carcinogenic PAHs only.
4. Details of screening procedures are provided in Section 7.2.

In addition to bulk sediment parameters, ammonia and sulphide measurements were made in porewater samples extracted from the bulk sediments in the laboratory. Sulphides were not detected at 0.02 mg/L in any samples, and ammonia concentrations were within a factor of two of reference (and were sometimes lower). These results indicate lack of sediment anoxia to a degree that would complicate the interpretation of toxicity test results between exposed and reference locations.

2.6 Management Units

As indicated in Section 1.3 (General Approach), a point of departure of the risk refinement, relative to the RMC-ESG (2014) deliverable package, is the degree to which risk evaluations were made spatially explicit. This means that separate risk conclusions for each receptor type were made based on the different conditions of exposure encountered in each portion of KIH. The KIH is a large and complex area of sediment contamination, with different contamination profiles found in different portions of the sediment bed, and different riparian and habitat conditions. FCSAP Expert Support raised several concerns regarding the exposure averaging methods in previous risk characterizations of KIH that have now been addressed through the specification of management units.

Management units for KIH were originally developed to identify data gaps in sediment chemistry, toxicity, and benthic invertebrate community structure prior to the implementation of the PQRA field program conducted by Golder (2011). Although those management units were appropriate for their intended purpose, it was necessary to revise these management units for the risk refinement. The newly defined units, as depicted in Figure 2, reflect several considerations:

- Water lot boundaries reflecting different ownership/jurisdiction (e.g., Transport Canada versus Parks Canada; federal versus private lot);
- Recent updates to our knowledge of sediment quality in KIH (e.g., changes to contaminant gradients through addition of sampling points);
- Aggregation of areas with similar effects (e.g., toxicity results and/or benthic community patterns, indicating commonality in biological responses);
- Specification of nearshore areas with increased potential for wading or other human recreational use;
- Aggregation of areas with similar habitat and riparian features, to provide a linkage to wildlife exposures and to discriminate shoreline areas with different potential for human use (e.g., attractiveness and accessibility to recreational users);
- Identification of zones with a spatial scale that is relevant to home ranges of wildlife that have high site fidelity;
- A spatial scale of management units that is appropriate for the sampling resolution (i.e., sufficient coverage of sediment quality data to calculate a reliable spatially-weighted exposure point concentration); and
- Limitations in the accuracy of dredging methodologies (i.e., management units should not have level of spatial detail or odd shape that is impractical in terms of physical limitations of large-scale dredging programs, or beyond the precision of a delineation program used to establish dredge cuts).

Placement of boundaries between management units considered the sediment chemistry distributions. This separated areas with relatively clean sediment where management is not necessary (TC-E and PC-N), from those with one or multiple COPCs where adverse effects may exist (**Figure 2).** The boundary definitions within the Western KIH zone also provided aggregation of areas with similar sediment chemistry profiles:

- **PC-W—**Parks Canada Zone (West): Defined as near shore conditions closest to the former Belle Landfill and exhibiting the highest concentrations of chromium, lead, PCBs, and PAHs in the Parks Canada water lot.

- **PC-E—**Parks Canada Zone (East): Defined as the remaining areas of the Parks Canada water lot having lower metal, PAH and PCB concentrations relative to PC-W.
- **TC-OM—**Near-shore management unit closest to the Orchard Street Marsh, former Davis Tannery and lead smelter. These sediments exhibit the highest concentrations of sediment chromium observed in the Transport Canada water lot.
- **TC-RC—**Near-shore management unit closest to the Kingston Rowing Club. This management unit contains sediment with high concentrations of arsenic, mercury, PAHs, and PCBs despite a localized dredging program conducted in 2005 to remove PCB contaminated sediment. The TC-RC unit includes sediment adjacent to Emma Martin Park, where the City of Kingston recently implemented upland source control measures to manage soil and groundwater contamination, particularly for arsenic. Groundwater remediation using an underground permeable reactive barrier was used to prevent additional contamination of waterlot sediments.
- **WM—**Privately owned water lot not managed by PC or EC. Near shore management unit closest to the Woolen Mill with sediment concentrations of PCBs, PAHs and several metals (arsenic, lead, and mercury) similar to those observed in the TC-RC water lot.
- **TC-1—**North central management unit containing elevated concentrations of antimony, chromium, and PCBs, although less heavily contaminated relative to nearshore units. Concentrations of several COPCs are low relative to other management units in KIH (e.g., PAHs, arsenic, lead).
- **TC-2A—**Near-shore management unit along the northern portion of Douglas Fluhrer Park. Moderate sediment concentrations of antimony, chromium, lead, PAHs, and PCBs, and elevated concentration of mercury, silver, and zinc relative to other KIH management units. Contains higher concentrations of mercury and silver compared to the neighbouring Douglas Fluhrer Park management units (TC-2B and TC-3A).
- **TC-2B—**Central management unit immediately south of TC-1 having similar sediment concentrations to TC-1.
- **TC-3A—**Near-shore management unit along the central portion of Douglas Fluhrer Park. Moderate sediment concentrations of antimony, chromium, lead, mercury, silver, PAHs, and PCBs relative to other KIH management units
- **TC-3B—**Central management unit immediately south of TC-2B having similar sediment concentrations to TC-1 and TC-2B.
- **TC-4—**Near-shore management unit along the south portion of Douglas Fluhrer Park. Moderate sediment concentrations of antimony, chromium, lead, mercury, silver, and PCBs, and high concentration PAH concentrations relative to other KIH management units. Contains higher concentrations of lead and PAHs compared to the neighbouring Douglas Fluhrer Park management units (TC-2A and TC-3A).
- **TC-5—**Southernmost central management unit immediately south of TC-3B. Sediment contaminant concentrations are among the lowest in KIH with the exception of elevated PAH along the eastern edge of the management unit that borders TC-AB.

- **TC-AB—**Nearshore management unit that encompasses Anglin Bay. Sediment contains elevated concentrations of PAHs and several metals including TBT, antimony, copper, and zinc believed to be related to current and/or historical ship building/maintenance activities in the area. PAH concentration distributions in this management unit are complex (heterogeneous), and include significant concentrations of PAHs below the biologically active sediment layer.

In the FCSAP Expert Support review of the draft risk synthesis, the issue was raised of variability in sediment concentrations within each management unit. Specifically, although it was recognized that division of the site into management units has allowed for better spatial assessment and management of potential ecological risks in the KIH, the "potential for sub-areas with possible hot spots (higher concentrations) to be missed" remains an uncertainty. Although localized sub-areas with concentrations higher than the EPC will occur in each management unit, there will also be sub-areas with concentrations lower than the EPC. Provided that the management units are defined with an appropriate spatial scale (i.e., relevant to the foraging patterns and averaging of exposure experienced by organisms over time), and with sufficient and representative data coverage, the EPC in each management unit remains the most relevant measure of chronic exposure. For sessile organisms, such as some benthic invertebrates, localized departures from the EPC could have a greater effect to some individuals; however, at the community level of organization, the EPC provides a sound basis for conveying ecological risk. Furthermore, even where highly localized hot spots exist, the ability to delineate sediment chemistry with confidence and precision is limited, and over-specification could result in impractical configurations of management units. Finally, even where the contaminant distributions of individual substances are precisely known, the spatial distributions of other substances of concern are not perfectly correlated. When the causal agent(s) are not known definitively, the risk characterization for contaminated sediments inherently includes a blending of estimated risks from multiple substances simultaneously; in this situation there is no reliable method for quantifying risk at a highly detailed level of spatial resolution. This issue was discussed with PWGSC, and the decision was made to retain the existing specification of management units; this level of resolution is adequate to support broad-scale remedial options evaluation. Once a conceptual remedial strategy is selected, it may be prudent to revisit the issue of management unit boundaries, with confirmatory sampling conducted only in areas where the detailed remediation plan requires increased precision.

3.0 BENTHIC INVERTEBRATE COMMUNITY ASSESSMENT

Risks to benthic invertebrate communities have been summarized using a weight-of-evidence approach, with conclusions rendered for each newly defined management area. Most of the applicable data and lines of evidence were already considered in the RMC-ESG (2014) deliverable package. However, several developments warrant a refinement of the risk characterization provided by RMC-ESG, all of which relate to Expert Support feedback:

- Some additional toxicity data has been recently collected in the Parks Canada Zone (Golder 2013a) including sediment chemistry and toxicity tests. Furthermore, recent sediment quality investigations near Anglin Bay have reemphasized the importance of PAH contamination in that portion of KIH, an issue that is given only cursory attention in RMC-ESG (2014). Incorporating these additional results fulfills the Expert Support request for a comprehensive evaluation using all existing data.
- The Options Analysis (Chapter V of the RMC-ESG deliverable package) did not formally evaluate the spatial distribution of risk to benthic communities, nor develop sediment quality objectives (SeQOs) protective of this receptor group. Instead, RMC-ESG relied on CRSG stakeholder consultation that, in their opinion, “affirmed protection goals based <only> on risk to humans and upper-trophic-level receptors.” FCSAP Expert Support has confirmed that to be consistent with the COA Framework, consideration of the magnitude and distribution of benthic community risks and risks to fish health is required.
- The existing data must be organized with the new management units. Benthic invertebrates have very high site fidelity relative to other receptors, and no aggregation of results across multiple units is required. However, a risk characterization conclusion specific to each management unit is required to follow the intent of the COA Framework.

The sediment quality triad integration procedure entailed compilation of chemistry, toxicity, and benthic community studies conducted previously by Golder (2011, 2012, 2013a) and historical information presented in ESG (2014) and other sources. Spatial characterization using the Sediment Quality Triad (sediment chemistry, toxicity and benthic community structure) in accordance with the COA Framework was previously conducted on a station-specific basis, but was refined here to assess the potential overall effects to the benthic invertebrate community at the scale of the management units.

3.1 Management Unit Sediment Concentrations

The surface sediment inverse-distance weighting technique presented in **Figures 3 to 12** was used to provide exposure point concentrations on a unit-specific basis. First, estimates of the surface sediment concentrations for each COPC were calculated using IDW interpolation of known concentrations at KIH sampling locations. Rather than averaging contaminant concentrations in samples collected within a management unit, the IDW weighted surface was divided into 5×5 metre grid units, where each unit was designated a concentration based on the inverse-distance weighting. The average concentration of all the 5×5 m grids that compose a management unit was then calculated. The IDW approach was considered to be preferable to simple mathematical averaging because it accounts for the representativeness of each sampling point; because historical sampling has targeted areas of known or suspected contamination, simple averaging would be biased toward areas of over-represented higher-density sampling.

Average concentrations for ecologically-based COPCs are provided in **Table 2**. The average contaminant concentrations in **Table 2** were then assigned colour categories based on exceedances of increasing SQG thresholds, consistent with the category definitions provided in **Figures 3 to 12.**

Table 2: Kingston Inner Harbour Average Surface Sediment Concentration for COPCs using Inverse-Distance Weighting

Management Unit	Area (m^2)	Total PAH	Total PCB	Sb	As	Cr	Cu	Pb	Hg	Ag	Zn
PC-N	1,244,981	1.84	0.03	NA	2.48	67.6	31.8	51	NA	0.36	192
TC-E	836,167	2.43	0.12	NA	3.34	209	36.5	59	NA	0.49	141
PC-E	95,270	5.97	0.18	1.92	4.53	890	37.3	96	0.19	0.32	145
PC-W	72,956	20.4	0.55	2.98	6.89	3209	67.4	252	0.34	0.64	274
TC-OM	25,527	4.68	0.19	2.18	11.02	1208	41.8	129	0.46	0.59	165
TC-RC	35,679	37.7	0.4	6.6	79.5	782	56.7	166	1.33	2.08	197
WM	18,886	16.1	0.5	1.0	34.0	880	79.1	233	1.51	1.35	268
TC-1	260,987	3.45	0.42	1.76	6.15	902	43.0	112	0.34	0.59	161
TC-2A	50,720	5.15	0.38	1.23	15.36	522	67.2	148	1.09	2.01	363
TC-2B	82,290	3.70	0.57	2.98	6.50	691	55.8	117	0.35	0.88	184
TC-3A	41,283	5.16	0.53	1.05	13.37	597	58.5	154	0.80	1.14	220
TC-3B	30,826	3.26	0.58	1.55	5.81	513	46.4	100	0.31	0.71	176
TC-4	42,439	11.3	0.60	0.9	9.3	392	56.2	172	0.74	0.79	223
TC-5	91,852	6.16	0.22	1.47	4.61	212	45.4	79	0.22	0.50	153
TC-AB	43,687	8.59	0.31	1.97	6.61	244	124.6	127	0.30	0.64	235

Notes:

Concentrations are presented in mg/kg dry weight

Colour categories based the SQG thresholds provided in **Figures 3 to 12**

The average concentrations of IDW-weighted COPCs in each management unit are considered to provide the most appropriate exposure metric for evaluating risks to benthic invertebrates, once the Site is partitioned into management units of appropriate scale. Although localized sub-areas within each unit would exhibit small-scale variations in sediment chemistry that are above or below the average, these variations would be either small in magnitude or reflect small-scale variability. The protection goal for benthic invertebrates is to maintain an abundant, diverse, and productive community, particularly in terms of providing suitable food resources to higher trophic levels. Achieving this goal does not require that all individual organisms in all sub-areas be afforded the same level of protection.

3.2 Benthic Community COPC Refinement

The presence of chemical concentrations above sediment quality criteria is not necessarily indicative of benthic or toxicological impairment. Rather than pooling all COPCs into a single line of evidence for sediment chemistry (as was done previously for the PQRA and DQA prepared by Golder [2011, 2012]), the ecologically-based COPCs were further refined to identify the chemical parameters with the greatest potential to be bioavailable and/or toxic to invertebrates in KIH sediments.

The importance of a sediment COPC to the evaluation of benthic community risk is a function of the magnitude and consistency of response observed, either in the laboratory or the field, with exposure to elevated concentrations of that COPC. COPCs were identified as priority COPCs for the chemistry line of evidence in the assessment of biological effects if all of the following conditions were met:

- The parameter is not a nutrient. As discussed in Section 2.5.2, the KIH environment is eutrophic, with the degree of enrichment by nitrogen, phosphorus, and organic carbon flat across the study area, reflecting background levels of nutrient enrichment. Concentrations of that COPC exceed sediment effects benchmarks indicative of a moderate potential for harm (i.e., upper-bound sediment quality guidelines such as PEL, LAET, LEL, SEL) in at least one sample. Although lower-bound guidelines such as the ISQG are useful for initial screening of sediment chemistry, the rate of false positives is high for ISQG exceedances.

- Concentrations of that COPC are elevated above benchmarks in areas with either benthic community impairment (**Figure 14**) and/or sediment toxicity (**Figure 15**). This is the most important criterion for evaluating the importance of individual constituents, as it reflects results of site-specific studies.

The hazard ranking conveyed in Table 2 is intended to provide neither a precise nor definitive assessment of potential for ecological harm. Rather, it is intended to facilitate identification of the substances that are most likely to explain variations in biological responses to benthic organisms, and for which more detailed evaluation of potential risk is warranted. For example, it is apparent in both **Table 2** and **Figure 10** that the gradients in sediment zinc concentrations are weak, and that the magnitude of toxicological hazard for zinc is low in relation to SQGs and also relative to other COPCs. Conversely, PAHs and chromium exhibit stronger spatial gradients in exposure and high toxicological hazard in some management units in relation to SQGs. These patterns indicate that PAHs and chromium warrant more attention in the assessment of concentration versus biological response.

3.2.1 Metals

Appendix A Figure A-1 presents rank ordered metal concentrations for ecologically-based COPCs and the associated toxicological or benthic community assessment results. There are some indications of an association between concentrations of copper, lead, silver, and possibly zinc (relative to sediment quality criteria as presented on the figures as dashed lines) and negative biological effects (indicated by yellow or orange bars); however, these associations were not strong. Despite concentrations of several metals in excess of sediment quality criteria, the distribution of sites with benthic community impairment and/or toxicological impairment suggests that the relationship between metals concentrations and observed biological responses is weak. Because of the potential for concentration-response relationships for copper, lead, and silver to be obscured by trends for other COPCs, it was conservatively assumed that these metals may be contributing to the overall pattern of response and therefore retained as priority COPCs for the sediment chemistry line of evidence.

Lack of strong association is also observed for antimony, arsenic, cadmium, iron, nickel, and chromium. For these metals, one of the following two patterns was evident:

- metal concentrations exceed higher sediment guideline values (e.g., OMOE SELs) but do not result in biological impairment, (i.e., arsenic and chromium); or

- impairment is observed, but occurs throughout the concentration gradient without any indication of concentration-response (i.e., antimony, cadmium, iron, and nickel).

Neither of the above patterns is suggestive of a cause-effect mechanism.

The apparent lack of response to elevated chromium at KIH likely results from the sediment chromium being predominantly present in the less toxic trivalent form. Previous studies (ESG 2014, Golder 2011) have confirmed that environmental media from KIH contain negligible to low concentrations of hexavalent chromium. This observation is further supported by the TIE investigation conducted as part of the DQA by Golder (2012a) to identify potential causes of sediment toxicity. The investigators concluded that neither chromium nor cationic metals (e.g., copper, cadmium, lead, nickel, zinc) were dominant toxicants in the KIH sediments tested, despite elevated concentrations of these substances in sediment relative to SQGs. The TIE findings and patterns of laboratory toxicity in field-collected sediments indicate that bioavailability and/or site specific toxicological factors limit the potential for adverse effects from exposure to sediment-associated metals.

In summary, evidence indicates that, at most, only a few metals (copper, lead, silver, and/or zinc) are indicative of potential to adversely affect benthic communities. In spite of generic guideline exceedances, the other metals and metalloids (antimony, arsenic, cadmium, iron, nickel, and chromium) are highly unlikely to be associated with biological impairment in KIH sediments, and as such, these metals were not carried forward as priority COPCs for the chemistry line of evidence in the refined Sediment Quality Triad (**Section 3.4**). Sediment mercury concentrations did not demonstrate a strong relationship to benthic or toxicological impairment. Mercury was not identified as a priority COPC for the evaluation of benthic community responses, but was separated identified as a biomagnifying COPC for consideration in the fish health, wildlife, and human health assessments.

3.2.2 PCBs

There is neither a clear nor consistent relationship between PCB concentrations and toxicological or benthic community effects (**Appendix A Figure A-1).** The TIE conducted as part of the DQA (Golder 2012) also did not provide evidence for the contribution of PCBs to observed toxicity. Therefore PCBs were not carried forward as priority COPCs for the chemistry line of evidence in the refined Sediment Quality Triad.

As a check on the above decision, we compared the concentrations of PCBs observed in KIH with those documented in published studies that have evaluated the strength of causation between PCB exposure and benthic community effects. For example, Fuchsman et al. (2006) concluded that direct effects to aquatic biota, although relevant to PCBs, do not occur until concentrations much higher than most co-occurrence based sediment quality guidelines. Evidence comes from several sources, including:

- Reverse-calculated sediment thresholds derived from tissue-based thresholds.
- Toxicity-based assessment (concentration-response) of sediment-associated PCBs from North American contaminated sites.
- Field studies of benthic community structure from North American contaminated sites.
- Mechanistic models of PCB toxicity (equilibrium partitioning) for PCB mixtures of relevance to the KIH composition (e.g., Aroclor 1254).
- Studies of spiked sediment toxicity using PCBs, which generally were consistent with EqP predictions.

We are not the first investigators to identify the disparity between generic SQGs for PCBs and the ecologically relevant thresholds observed in site-specific risk assessments. Becker and Ginn (2008) provide a critical assessment of SQGs of PCBs based on the original documents and databases used to develop the underlying SQGs, as well as the original documents and data sets used to determine the predictive ability of these thresholds.

They concluded that:

> *Site-specific application of the SECs [sediment effect concentrations] indicated that their predictive ability was very low, that concentration-response relationships were not found for a variety of test species and toxicity endpoints at PCB concentrations greater than the SECs, and that some of the highest survival and growth values in the toxicity tests were found at PCB concentrations considerably greater than the SECs. Based on the results of this study, we conclude that the SECs for PCBs should be used only in the screening-level evaluations that typically precede more direct assessments of sediment toxicity at individual study sites, and should not be used to predict the presence of sediment toxicity. Contrary to the conclusions of the SEC developers, the SECs do not reconcile existing SQGs, do not reflect causal effects, and should not be used to determine the spatial extent of injury to sediment-dwelling organisms.*

Our investigation confirms the findings of Becker and Ginn (2008) and Fuschman (2006) and incorporates additional data sets not considered by these authors, thus strengthening their findings. Our literature reviews indicate that a more meaningful threshold for PCB effects to benthic invertebrates is 1.0 mg/kg dry weight, representing the transition from negligible risk to low risk. The equivalent threshold on an organic-carbon normalized basis is 30 mg/kgOC which converts to 3 mg/kg dw for sediments containing approximately 10% TOC. The concentrations of PCBs in the KIH, although elevated in some individual samples, are not sufficiently high to result in low-level responses to benthic invertebrates. Therefore, the decision to exclude PCBs from consideration as priority COPCs for the chemistry line of evidence was affirmed. PCBs were not identified as a priority COPC for the evaluation of benthic community responses, but was separated identified as a biomagnifying COPC for consideration in the fish health, wildlife, and human health assessments.

3.2.3 PAHs

Although the statistical associations between biology and toxicity measures and PAH concentrations in sediment do not provide definitive evidence of causation (Golder 2012), a greater occurrence of both biological and toxicological effects has been observed in KIH sediments with elevated PAH concentrations. These responses were observed at PAH concentrations greater than the CCME PEL (**Appendix 1 Figure A-1**). Furthermore, the TIE conducted in support of the DQA (Golder 2012a) on two samples exhibiting toxicity (2011-C and 2011-A) provided indications that PAHs were responsible for adverse responses:

- increased toxicity of the 2011-C sample associated with exposure to UV suggests that photoactivated PAHs were present in this sample;
- the increase in toxicity associated with UV was substantial, and provided a strong line of evidence that photo-activated organic toxicants were present; and
- increased toxicity to *Chironomus* associated with treatment with SIR-300 was consistently observed using sample 2011-C, and also occurred with sample 2011-A, suggesting the presence of a similar physico-chemical property in both samples.

As such, PAHs were retained as priority COPCs for the sediment chemistry line of evidence. Of all the COPCs evaluated, the evidence for causation (i.e., indication of biologically meaningful and site-specific effects directly linked to magnitude of exposure) was greatest for this contaminant group.

3.3 Biological Effects

Although sediment chemistry parameters provide indications of potential for harm, the most reliable indicators of risk to benthic communities come from the site-specific studies of biological responses. Laboratory toxicity tests indicate whether the mixtures of contaminants found at each station elicit responses to sensitive freshwater organisms under controlled laboratory conditions. These tests account for the site-specific factors (bioavailability, speciation, substrate conditions) that mediate the toxicity of contaminants in field sediments. The benthic community endpoints provide direct measures of the biological attributes of interest, specifically the abundance, diversity, and overall composition of the resident benthos. Benthic community studies are prone to high variability due to the multitude of physical, chemical, and biological (habitat) factors that may shape the community composition at any specific location. However, the composition of benthic communities provides a meaningful test of whether site contaminants have exerted a significant influence on the resident biota, particularly when comparisons are made to appropriately matched reference conditions.

Figures 14 and 15 provide graphical summaries of the biological and toxicological endpoints considered in the integrated assessment, including:

- Survival responses from sediment toxicity test results;
- Growth responses from sediment toxicity test results;
- Overall pattern of whole sediment toxicity (i.e., aggregation of toxicity endpoint response);
- Total abundance of organisms (i.e., a measure of biological productivity);
- Taxonomic richness (i.e., a measure of biological variability and suitability for a broad assemblage of taxa);
- Simpson's Index of Diversity;
- Shannon-Wiener Index of Diversity; and
- Overall benthic community response (i.e., aggregation of properties of the biological assemblage).

Due to differences among sampling programs (e.g., changes in reference sites, different sieving procedures for benthic collections, changes to toxicity test protocols) it was necessary to convert endpoints to a common "currency". This was conducted previously for the PQRA and DQA conducted by Golder (2011, 2012) by standardizing all responses to the most relevant reference (or control) for each study, and applying 20% and 50% effect-based thresholds systematically to all biology and toxicity measurement endpoints, consistent with the COA Framework decision rules.

Detailed methodologies for the categorization for benthic community impairment (Figure 14) and sediment toxicity (Figure 15) are provided in the DQRA by Golder (2012a). The primary method used to evaluate toxicity test data was through calculation of 20% of 50% inhibitions of endpoints relative to the mean of the reference sediment responses. This is consistent with the COA Framework in terms of the methods used to identify minor and major toxic responses. These assignments were also used for benthic indices and integrated using the COA Framework decision rules similar to those applied for toxicity endpoints (i.e., "possibly different" is equivalent to "multiple metrics exhibit minor biological responses and/or one metric exhibits a major response").

Upon review of the draft risk synthesis report (Golder 2015), FCSAP Expert Support requested additional rationale for the selection of the effect-size based categories (i.e., references for the benthic community and sediment toxicity categories applied in **Figures 14 and 15**). In addition to the rationale provided in EC and OMOE (2008), support for the use of the inhibition concentration (IC_X) approach, and specifically the IC_{20} to discriminate between “negligible” and “potential” risk categories, comes from the following:

- Most toxicity tests applied in the assessment of chronic toxicity only have the statistical power to effectively detect a 20% to 30% deviation from control (Nautilus and Zajdlik 2011; Suter et al. 1995; US EPA 2013b). Although smaller endpoint sizes are often calculable, the associated test variability results in low statistical power, such that derived IC_X estimates are uncertain. Lower effect sizes are not likely to be reliable estimates of the effect sizes they are meant to represent. This is because as “x” becomes smaller, the confidence limits on IC_X increase and the precision of the point estimate decreases.

- Environment Canada (2005) advises against estimating an endpoint within the acceptable range of effect in the control(s). Beyond that point, any IC_X would be suspect if it was below the lowest effect observed for the test concentrations. Because chronic toxicity tests typically have acceptable control responses of up to 20%, there is an increased risk of false positives when small effect thresholds are calculated.

- The US EPA has used the IC_{20} to represent a low level of effect in derivations of ambient water quality criteria for freshwater aquatic life. This has been done for ammonia (US EPA 1999, 2013b) and copper (US EPA 2007). US EPA selected IC_{20} values to be used to estimate a low level of effect that would be statistically different from control effects, yet not so severe as to be expected to cause chronic impacts at the population level (US EPA 2013b).

- Ecological risk assessment guidance often recommends the use of IC_{20} results as a permissible level of effect. For example, an effects level for ecological assessment endpoints lower than 20% would appear to be acceptable based on current US EPA regulatory practice and could not reliably be confirmed by field studies, and can therefore be considered *de minimis* (Suter et al. 1995).

- Mebane (2010) supports the use of an effects level of 20% for protection against unacceptable adverse effects on populations of invertebrates. For fish, similar reductions of about 20% "in growth or first year survival likely would be sustainable" in fish populations that are reasonably stable, where habitats were intact and environmental conditions not otherwise severe.

3.4 Integrated Assessment

Using the information provided in **Table 2**, and **Figures 14 and 15**, it is possible to reach broad conclusions regarding the weight of evidence for benthic community impacts in each of the sediment management units. Sediment chemistry, toxicity and benthos alteration lines of evidence were evaluated for management units based the COA Framework, and are summarized using the criteria specified in **Table 3**.

Where individual management units lacked data to determine sediment toxicity or benthos alteration (i.e., TC-3A, PC-W and WM), the potential for toxicity or benthos alteration was interpolated from adjacent management units with similar sediment type, and included in the line of evidence. In these cases, the assignment of potential for sediment toxicity or benthos alteration was based on the concentration-response that was observed from adjacent management units, especially those with similar sediment contamination and substrate type. The interpolation for each management unit was as follows:

Table 3: Ranking System for the Overall Effects to Benthic Invertebrates Weight of Evidence

Category (Source)				
Sediment Chemistry (Table 2)	**Low Concentrations:** Management unit weighted average concentration in the blue or green category exceeding only the most conservative sediment quality guidelines (*e.g.,* ISQG).	**N/A**	**Moderate Concentrations:** Management unit weighted average concentration in the yellow or light orange categories, which exceed less conservative sediment quality criteria (e.g., PEL) having potential for effects on aquatic life.	**High Concentrations:** Management unit weighted average concentration in the dark orange or red category, which exceed the least conservative sediment quality criteria (e.g., SEL) having increased potential for effects on aquatic life.
Benthos Alteration (Figure 14)	**Negligible Differences Relative to Reference:** Benthic communities at all stations within the management unit similar to reference communities (green dots).	**Localized Potential Differences to Reference Conditions:** No adverse effects at most stations. One or more stations different than reference stations, but isolated to a small portion of the management unit, and not considered to broadly represent the benthic community throughout the management unit.	**Potentially Different than Reference Conditions:** One or more stations are potentially different than reference stations, but magnitude of response limited. Results considered to be representative of management unit as a whole.	**Significantly Different than Reference Conditions:** Management unit has one or more stations that are significantly different than reference stations (larger degree of impairment). Responses considered broadly representative of management unit as a whole. May also contain stations classed as potentially different.
Overall Toxicity (Figure 15)	**Negligible:** Toxicity for all stations within the management unit is negligible (green dots)	**Localized Potential:** One or more stations exhibit potential (yellow) or significant (orange) toxicity. However, effects isolated to small portion of a management unit and not considered to broadly represent conditions throughout the management unit.	**Potential:** One or more stations having shown potential toxicity are representative of management unit as a whole.	**Significant:** Management unit has one or more stations having shown significant toxicity are representative of management unit as a whole. May also contain stations with potential toxicity.

Category (Source)				
Overall Effects to the Benthic Community (Table 4)	**No Adverse Effects:** Low to moderate chemistry with no potential toxicity or potential differences in benthic community structure (may have localized potential).	**N/A**	**Potential Adverse Effects:** Moderate to high chemistry with potential toxicity and/or potential differences in benthic community structure.	**Adverse Effects Likely:** Moderate to high chemistry with significant toxicity and/or significant differences in benthic community structure.

- **Woolen Mill (WM)—**The benthos alteration line of evidence was inferred to be equivalent to reference based the results observed in the management unit TC-RC which shared similar distributions of COPCs and toxicity testing results.
- **Parks Canada East (PW-W)—**The benthos alteration line of evidence was inferred to have a "localized potential" for alteration, particularly in the vicinity of the Orchard Street Marsh, based the results observed in the adjacent management units PC-E and TC-OM, which shared similar distributions of COPCs and toxicity testing results.
- **Transport Canada (TC-3A)—**The sediment toxicity endpoint was inferred to be "negligible" toxicity. This inference was made based on the lower concentrations of contaminants observed in TC-3A compared to the neighbouring Douglas Fluhrer Park management units (TC-2A and TC-4), and the benthic community structure in TC-3A which was more similar to reference conditions than neighbouring management units.

The inferences made in the above bullets convey additional uncertainty relative to the stations and management units that have data for all three SQT components. We concur with FCSAP Expert Support's comment that "insufficient data should not be confused with a lack of adverse effect." However, there was a sufficient number of toxicity and benthic community samples in the overall program that interpolation using concentration-response information from adjacent sediment parcels is a reasonable approach to fill data gaps. Moreover, the desire to incorporate site-specific toxicity and biological composition data in the weight of evidence for each management units is one of the reasons why the spatial scale of management units was not further reduced (i.e., smaller units would increase the need for interpolation of response data). Biological and toxicological evaluations using the Sediment Quality Triad revealed that adverse responses are evident for some endpoints and management units. **Table 4** summarizes the COA Framework conclusions for the KIH benthic community weight of evidence.

The interpretations of the WOE findings have value for making broad statements regarding risks to benthic invertebrates. However, because different lines of evidence confer different differ types of information; the patterns of responses were evaluated in terms of consistency, evidence for causation, and degree of associated uncertainty. A narrative summary of these findings is provided below:

- **Adverse Effects Likely—**Transport Canada management units TC-4 and TC-AB were identified based on low abundance and diversity of benthic taxa (relative to reference), significant toxicity to sensitive invertebrate taxa in the laboratory, and indications of PAH effects on toxicity and benthic community endpoints. These management units correspond to historical contamination from a former rail yard and coal gasification plant.

- **Potential Adverse Effects—**Transport Canada management units TC-5, TC-3B, TC-2A and TC-2B. Management units were determined to have sediments with the potential to be toxic, as well as stations with potential or localized potential differences in terms of benthic community structure. Although the possibility of natural factors have resulted in differences in the benthic community for TC-5, TC-3B and TC-2B, the overall weight of evidence is considered sufficient to assign these stations to the "potential adverse effects" category.
- **Adverse Effects Unlikely—**All remaining management units. Management units PC-N, TC-OM, TC-RC and WM exhibited strong evidence for the confusion of lack of adverse effects, as no indications of benthic alteration or sediment toxicity were observed. Although stations TC-E, PC-E, PC-W, and TC-1 have some localized potential for benthic alteration or sediment toxicity, the overall evidence is indicative of negligible to low level responses, and with any responses limited in spatial scale, which is considered sufficient to assign these management units to the “adverse effects unlikely” category.

Table 4: Weight of Evidence Categorization for Sediment Chemistry, Toxicity and Benthos Alteration and Overall Benthic Community Effects

Management Unit	Sediment Chemistry for Priority COPCs					Sediment Toxicity Endpoint	Benthos Alteration Endpoint	Overall Effects to the Benthic Community
	Cu	Pb	Ag	Zn	PAHs			
PC-N	Low	Low	Low	Low	Low	Negligible	Negligible	No Adverse Effects
TC-E	Low	Low	Low	Low	Low	Negligible	Localized Potential	No Adverse Effects
PC-E	Low	Mod.	Low	Low	Mod.	Localized Potential[2]	Localized Potential	No Adverse Effects
PC-W	Low	Mod.	Mod.	Low	Mod.	Insufficient data	Localized Potential	No Adverse Effects
TC-OM	Low	Mod.	Mod.	Low	Mod.	Negligible	Negligible	No Adverse Effects
TC-RC	Low	Mod.	Mod.	Low	High	Negligible	Negligible	No Adverse Effects
WM	Low	Mod.	Mod.	Mod.	Mod.	Negligible	Insufficient data	No Adverse Effects
TC-1	Low	Mod.	Mod.	Low	Low	Localized Potential	Localized Potential	No Adverse Effects
TC-2A	Low	Mod.	Mod.	Mod.	Mod.	Potential	Potentially Different	Potential Adverse Effects
TC-2B	Low	Mod.	Mod.	Low	Low	Potential	Localized Potential[1]	Potential Adverse Effects
TC-3A	Low	Mod.	Mod.	Low	Mod.	Insufficient data	Negligible	No Adverse Effects
TC-3B	Low	Mod.	Mod.	Low	Low	Potential	Localized Potential[1]	Potential Adverse Effects
TC-4	Low	Mod.	Mod.	Low	Mod.	Significant	Localized Potential	Adverse Effects Likely
TC-5	Low	Low	Low	Low	Mod.	Potential	Localized Potential[1]	Potential Adverse Effects
TC-AB	Mod	Mod.	Mod.	Low	Mod.	Potential	Significantly Different[1]	Adverse Effects Likely

(1) Denotes stations for which lower abundance and/or proximity to macrophytes may have resulted in different benthic communities due to natural factors.
(2) While significant toxicity was observed for one station, no toxicity was observed at the majority of the surrounding stations suggesting localized potential.

3.5 Uncertainties

Sediment quality triad (SQT) assessments are designed to reduce uncertainty by including different types of data so that the limitations of any individual line-of-evidence are balanced against the strengths of another line-of-evidence. However, there were several sources of uncertainty in the current assessment that should be considered:

- **Representativeness of Chemistry Data—**Although the sample stations were well distributed throughout KIH, we cannot rule out the possibility that localized areas with elevated contamination have not been sampled. However, given the large number of samples and the distribution of sampling stations within KIH, the likelihood that large areas of elevated contamination have not been detected is small. Furthermore, a gradient-based study design was implemented, such that benthic and toxicity test samples that were collected are considered to be representative of the range of COPC concentrations present in KIH. The region of greatest uncertainty is the area within and adjacent to Anglin Bay, due to the heterogeneous distribution of PAH contamination is this area. Supplemental sampling was undertaken by Transport Canada in 2003 (Golder 2014) that indicated pockets of high PAH concentrations at both surface and depth, but these were not distributed evenly in the vertical or horizontal dimension.

- **Representativeness of Toxicity Data—**The toxicity assessment incorporates uncertainties related to lab-to-field extrapolation, because responses observed in the laboratory do not always translate to bioavailability/toxicity in the receiving lake environment. The toxicity testing conditions in the laboratory may enhance/reduce contaminant bioavailability due to manipulation during sample collection, sample processing, and testing. Toxicity tests evaluate toxicity at the individual level without consideration of population or community dynamics, and rely on the representative of specific invertebrate test species as surrogates for ecosystem responses. Environment Canada (2005) acknowledged that formal attempts to establish whether a particular toxicity test is representative of the much larger free-living (wild) populations of organisms are rare, but also concluded that most deliberate trials of field validation confirm that toxic levels determined in the laboratory are good predictors of harmful effects to natural communities. Environment Canada (1999) provided a major review of laboratory-to-field extrapolations, and concluded that in most cases, the laboratory tests were good predictors of effects in natural habitats. For KIH, a fairly robust battery of tests has been applied in part toxicity testing programs. Whereas recent studies have emphasized *Hyalella azteca* and *Chironomus tentans*, which were the most sensitive species tested, earlier testing also included a mayfly (*Hexagenia sp.*), fathead minnow (*Pimephales promelas*), and Microtox™ toxicity using the luminescent bacteria *Vibrio fischeri*.

- **Representativeness of Benthic Community Data—**Whereas benthic community data provide a direct measurement of the ecological attributes of interest (i.e., presence of a diverse, productive, and balanced community of invertebrates) such studies are prone to confounding factors not related to the effects of sediment contaminants. The presence of high variability both within and among stations can obscure the ability to evaluate concentration-response relationships. Potential confounding factors in lake environments can include: habitat-related influences such as water depth, presence of macrophytes, substrate type (grain size, organic carbon, and other particle related factors), dissolved oxygen condition, degree of artificial disturbance (e.g., prop-wash or burrowing of fish and wildlife). Therefore, in interpreting the biological significance of benthic community data, a common problem relates to the ecological importance of small shifts in community composition.

- **Interpolation of Toxicity and Benthic Community Data—** For management units missing the sediment toxicity or benthos alteration lines of evidence, the potential for toxicity or benthos alteration was interpolated. This interpolation was based on the concentration-response that was observed from other locations, especially those nearby with similar sediment contamination and substrate type. However, we cannot rule out the possibility that areas with elevated contamination have not been sampled, or that if samples were tested other confounding factors may have resulted in a classification of sediment toxicity or benthos alteration lines of evidence different to the inference made.

Considering the above factors, it is apparent that conclusions for any individual management unit or any individual line of evidence have lack of precision associated with the uncertainties discussed above. However, when considered in aggregate, the conclusions are strengthened, and it is unlikely that conclusions reached using the WOE Framework would be substantially misaligned with the true responses in the field. The three categories identified in the COA Framework provide a suitable level of resolution for use in risk management process. Should additional precision or reduced uncertainty be required at a later stage of risk management (e.g., once a conceptual remedial option be selected for implementation), further investigation in the field could reduce the uncertainties identified above.

4.0 FISH HEALTH ASSESSMENT

4.1 Methods

Two approaches were used to assess risks to fish health:

- Tissue Residue Assessment—The tissue residue approach entails comparison of tissue concentrations of COPCs toxicity thresholds (sometimes called critical body residues). The hazard quotient method is used to compare observed concentrations to the toxicity thresholds. RMC-ESG (2014) provided a summary of fish toxicity thresholds obtained from a review of the relevant scientific literature. Their assessment included inorganic metals (arsenic, copper, lead, zinc), organic mercury (methylmercury), and total PCBs. Expert Support did not raise significant concerns regarding the tissue residue approach; therefore, these results were adopted for the risk refinement.
- Fish Deformity Evaluation—RMC-ESG (2014) identified brown bullhead as a sentinel species because of its very limited home range, strong connection to sediments due to life history characteristics, and evidence of deformities at other Great Lakes contaminated sites. Two types of information were evaluated with respect to potential for bottom fish deformities (field sampling and analysis for gross external signs of health impairment; literature review of sediment concentrations of COPCs associated with internal and external lesions).

The assessment of fish toxicity of PAHs is complicated by the fact that PAHs are readily metabolized by most aquatic animals, including teleost fish (Johnson et al. 2002). Although metabolism serves as a detoxification pathway for PAHs, some of the metabolites formed as intermediates during the detoxification process are carcinogenic, mutagenic, and cytotoxic (Johnson et al. 2002). As a result, PAH tissue concentrations derived using standard analytical methods are not a good indicator of fish exposure to these compounds.

4.2 Tissue Residue Assessment

RMC-ESG (2014; Table IV-32) provides a summary of hazard quotients for fish tissue chemistry, using 95% UCLM values and maximum concentrations of COPCs in fish tissues.

- Hazard quotients for arsenic, copper, and zinc were below 1.0, indicating negligible risk through accumulation in tissues for these substances.
- For other substances, hazard quotients calculated using the 95% UCLM for KIH tissue data were always below 1.0, but sometimes exceeded 1.0 using the maximum individual concentrations in the data set.
- For lead, hazard quotients using the 95% UCLM were greater than 1.0 only at the reference location. Using maximum concentrations, both KIH and the reference location exceeded the tissue benchmark (HQs of 3.3 and 3.8 respectively). Considering that concentrations in fish tissue were indistinguishable between the two locations, and that the highest HQ was observed in the reference area, risks to fish from lead bioaccumulation are considered to be negligible.
- For mercury, the maximum tissue concentration in KIH samples (0.29 mg/kg ww) marginally exceeded the tissue effects benchmark (HQ = 1.4). The concentrations observed in KIH fish samples were only slightly high than reference conditions, and this difference was not statistically significant.

- The PCBs, the maximum tissue concentration in KIH samples (5.7 mg/kg ww) marginally exceeded the tissue effects benchmark (HQ = 1.4).

These results indicate negligible to low risks from tissue accumulation of COPCs in KIH. Upon review of the draft risk synthesis (Golder 2015), FCSAP Expert Support commented on the HQ values for lead, noting that “a lack of difference between HQ values at the reference site and KIH sites should not be confused with ‘no risk’ to fish.” Although this is true in the strict sense, there are several reasons why the risk of lead to fish is considered to be negligible at this site:

- The HQ only exceeded 1.0 using maximum observed concentrations of lead in fish;
- Exceedance of HQ of 1.0, particularly by a small amount and using worst-case assumptions, does not convey evidence of harm but rather only the possibility of harm;
- The relative risk of tissue borne lead is negligible (i.e., KIH body burdens are lower than those upstream);
- The broad similarity of lead concentrations in fish between KIH and the Upstream Reference Zone is indicative of regionally elevated lead concentrations, to which fish are naturally adapted (acclimation and tolerance); and
- The distribution of sediment chemistry (**Figure 7**) also confirms the regionally elevated lead concentrations, as the Upstream Reference Zone sediment includes lead concentrations that often exceed ISQGs.

From a practical perspective, the marginal HQ values for lead observed in both KIH and the Upstream Reference Zone represent a very wide area for which physical management of lead contamination is impractical. There is no evidence that source areas within KIH are increasing the bioavailability or bioaccumulation of lead into resident fish species.

The magnitude of HQs for organic substances (mercury and PCBs) are generally low. Although Expert Support has correctly identified that as a general rule, HQ>1.0 cannot be discounted, there are several factors suggesting that the marginal HQ values for mercury and PCBs are not indicative of unacceptable risk. First, as discussed above for lead, the derivation of HQs based on maximum measured concentrations is highly conservative. Furthermore, there are multiple indications that the HQs calculated by RMC-ESG overstate the actual risks to fish even if maximum concentrations are assumed:

- The tissue benchmark for methylmercury selected by RMC-ESG was 0.21 mg/kg ww (Beckvar et al. 2005), which represents a conservative derivation relative to other assessments. For example, Sandheinrich and Wiener (2011) provide an updated summary of the environmental toxicology of methylmercury in freshwater fish. For protection against survival, growth, reproduction, and developmental effects (common endpoints for ecological risk evaluation), their compilation a wet weight muscle tissue concentration of 0.5 mg/kg ww may be considered as a threshold effects concentration for freshwater fish. Although some responses have been observed for some fish species below 0.5 mg/kg ww, these responses are limited to biochemical endpoints that are of questionable relevance to fish health.
- The tissue benchmark for total PCBs was 4.2 mg/kg ww (Hansen 1974), which represents a conservative derivation relative to other assessments. For example, Weston (2004) presents the results of a detailed literature review in which a total of 39 scientific papers were reviewed to identify the range of total PCB concentrations associated with adverse effects on survival, growth, and reproductive success in freshwater

fish. The review recommended a whole body tissue concentration of 31 mg/kg ww total PCB as protective of reproductive and developmental endpoints. Adult fish with tissue concentrations greater than 31 mg/kg ww may have reduced reproductive success and/or their offspring may experience adverse early life stage developmental effects. The review also indicated that warmwater fish species tend to have greater tolerance to PCB exposure relative to some coldwater species, such as sensitive strains of rainbow trout.

Overall, the marginal HQ values for tissue burdens of organic substances (i.e., maximum HQ of 1.4 for both mercury and PCBs) result from compounding conservatism in a screening level analysis. When recent technical assessments of toxicity of these substances to freshwater fish is considered, the HQs drop below 1.0 even when the maximum observed tissue concentrations are assumed as exposure estimates.

In summary, the comparison of tissue concentration data to environmental benchmarks indicated that risks to fish from bioaccumulation of PCBs, mercury, and inorganic metals in KIH is very low.

4.3 Fish Deformity Evaluation

4.3.1 Field Evaluations

RMC-ESG collected 14 brown bullhead in the northern section of KIH in fall of 2009, plus 19 at a reference site north of Belle Island. These fish were visually inspected for skin discoloration or black pigmentation, lesions and ulcers of the lip or body, fin and tail erosion, and missing, deformed or shortened barbels (RMC-ESG 2014). Of the 14 brown bullhead caught in the APEC (a region of sediment centered in the Parks Canada Zone), 11 bullhead (79 percent) suffered from one or more anomalies. In contrast, only two (11 percent) of the reference specimens exhibited any type of anomaly, and these reference-site brown bullhead anomalies were less severe.

Although RMC-ESG (2014) acknowledged the strong evidence in the toxicological literature that exposure to PAHs is linked with elevated levels of orocutaneous and liver tumours for brown bullhead (Rafferty et al. 2009; Blazer et al. 2009), they concluded that PAHs are "unlikely to be the cause of the tumours in the KIH fish as sedimentary PAH concentrations were generally low." This conclusion is not supported by the data, as the sediment exposure profile (**Figure 12**) indicates a substantial portion of KIH shoreline sediments contain more than 20 mg/kg total PAH.

4.3.2 Sediment Benchmark Evaluations

4.3.2.1 Literature Review

To help resolve some of the uncertainty in the evaluation of potential causes for the observed bullhead anomalies, PWGSC sponsored some desktop studies to evaluate the linkage between freshwater sediment contamination and bottom fish lesions. A literature review conducted by CLAW (2013) provided important information for the assessment and potential management of sediments in Kingston Inner Harbour with regards to impacts to fish health. First, it identified two groups of contaminants with significant potential to elicit the types of lesions observed in field-collected bullhead, either alone or in combination. One of these groups (PCBs) had already been identified by RMC-ESG (2014) as a potential toxicant. Golder’s review indicated that PAHs are a plausible explanation for the deformities. Based on the weight of evidence provided in the literature review, Golder (2013c) determined that PAHs are more likely to explain the observed lesions than are PCBs, based on the following:

- Greater evidence for a toxicity mechanism for PAHs, given the extensive laboratory work shown to elicit lesions in bullhead and other bottom fish following exposure to PAHs;

- More field evidence of empirical associations of PAHs with lesions and tumours, including multiple studies in Great Lakes environments; and
- Environmental concentrations of PAHs in KIH sediments that correspond well to the concentrations identified as having elevated potential to increase tumour prevalence.

Notwithstanding the above, PCBs remain as potential candidates for causing or contributing to the development of some of the observed lesions. In fact, several authors in the literature review (CLAW 2013) indicated the possibility that PCBs and PAHs may interact to cause increased prevalence of abnormalities. There is some evidence of this phenomenon at North American monitoring sites. For example, NOAA (2009) reports that the rates of PAH-associated health effects found in flatfish from a PAH contaminated site in Kitimat BC (i.e., liver lesion prevalences and DNA damage in sole) were lower than observed in other contaminated industrial areas such as Puget Sound, which have multiple contaminants (including PAHs and PCBs).

Based on the literature review findings (CLAW 2013), and an examination of dose response conducted by Golder (2013c), the following benchmarks are proposed to screen sediments for potential risk of increased bullhead lesion prevalence.

- **Total PAH (Low Risk)—4 mg/kg**—The 4 mg/kg dw benchmark corresponds approximately with the average PAH concentration causing 12% incidence of external lesions. This benchmark also corresponds to sediment PAH level that did not result in increased incidence of liver lesions above background rates. Below this concentration, no adverse effects to fish health are anticipated.
- **Total PAH (High Risk)—15 mg/kg**—The 15 mg/kg dw benchmark corresponds approximately with the average PAH concentration causing 20% incidence of external lesions. This benchmark also corresponds to the sediment PAH level drawn from field studies that distinguishes high and low incidence rates for incidence of liver lesions. For exposure concentrations above 15 mg/kg, only two data points show liver tumour incidence rates below 5%, whereas for exposure concentrations below 15 mg/kg, nearly all data points fall within the range of background liver lesion rates specified by Baumann (1999, 2002).
- **Total PCB (Low Risk)—0.3 mg/kg**—The 0.3 mg/kg dw benchmark corresponds approximately with the point of inflection in the relationship between PCB exposure and liver lesions. This concentration falls midway between the thresholds for potential impairment for external lesions. Below this concentration, no adverse effects to fish health are anticipated.
- **Total PCB (High Risk)—1.0 mg/kg**—The 1.0 mg/kg dw benchmark corresponds with approximately a 20% incidence of external lesions (on average) and a 40% incidence of liver lesions (on average). This represents an increased degree of tumour prevalence.

For the purposes of the updated effects assessment, third risk category was adopted representing a **moderate risk** to fish health. This refinement was made in recognition of FCSAP Expert Support feedback indicating that risk of increased deformities follows a spectrum rather than a definitive threshold. Because different stakeholders may have different opinions regarding the acceptable level of deformity incidence, multiple categories including a “moderate risk” category are useful. To determine concentrations of PAHs and PCBs above which would pose moderate risks to fish health, the maximum acceptable toxicant concentration (MATC) was calculated. The MATC was calculated as the geometric mean of the no observed effect concentration (NOEC; the low risk concentration) and the lowest observed effect concentration (LOEC; the high risk concentration) for both PAHs and PCBs.

Accordingly, surface sediment concentrations that exceed **8 mg/kg PAHs**, or exceed **0.5 mg/kg PCBs** would be considered of moderate risk to fish health.

4.3.2.2 Updated Exposure Profile for Bullhead

Brown bullhead (*Ameiurus nebulosus*) were selected as the fish health indicator species due to their persistence in KIH, relatively small home ranges, and high site fidelity. Brown bullhead are found in pools and slower-moving areas of creeks and rivers, reservoirs, ponds, and lakes, and are tolerant of a wide range of environmental conditions, including warm water temperatures and low oxygen levels, preferring habitats with vegetation and substrate. Much of the toxicological literature on abnormality incidence in bottom fish is based on this species. For example, elevated liver and skin tumor prevalence has been reported in brown bullhead from the tidal Anacostia River, Washington, DC (Sakaris et al. 2005).

Several studies have applied tracking methods (movement data) to effectively use tumor prevalence as an indicator of habitat quality. For example:

- Ultrasonic telemetry was used to verify the residency of adult brown bullheads in the Anacostia River during summer 2000, spring 2001, and fall–winter 2001–2002 (Sakaris et al. 2005). During summer, the linear home range was estimated to be 0.50 km, increasing to 1.0 km in spring, and 2.1 km in fall/winter. In comparison, the linear home range of fish released in Lake Kingman (a tidal freshwater impoundment of the Anacostia) was 0.58 km. No fish were located outside of the Anacostia River. We conclude that adult brown bullheads were resident in the system throughout the year.
- A mark-recapture analysis of brown bullheads in Presque Isle Bay (Millard et al. 2009) suggested that these migrated extensively within local territories but did not typically enter the open water of Lake Erie, and tended to remain within lagoons and coves that were approximately one square kilometer (each).

Given that brown bullhead exhibit linear home ranges as small as 0.5 km, but sometimes extending more than 1.0 km, and given that both fish movements and COPC distributions overlap the management units established for KIH (Section 2.6), the management units were combined to represent realistic home ranges for brown bullhead. Management units were combined to create four potential home ranges within Western KIH, each having linear distances of approximately 0.5 to 1.0 km and of similar area. Brown bullhead home ranges in KIH are presented in **Figure 17** and discussed below:

- **North Habitat—**Area: 19.4 ha. The northern fish habitat area is adjacent to the former Belle Landfill, Belle Island and the Orchard Street Marsh, which includes management units PC-W, PC-E and TC-OM. Water within this area is relatively shallow (approximately 1 m) and contains macrophyte beds.
- **North-Central Habitat—**Area: 29.7 ha. The north-central habitat area is adjacent to Kingston Rowing Club and Emma Martin Park, which includes management units TC-RC and TC-1. Water within this area is relatively shallow (approximately 1 m) and contains macrophyte beds.
- **South-Central Habitat—**Area: 22.4 ha. The south-central habitat area is adjacent to the Woolen Mill and Douglas Fluhrer Park, which includes management units WM, TC-2A, TC-2B, TC-3A, and TC-3B. Water within this area is relatively shallow (approximately 1-2 m) and contains macrophyte beds.

- **South Habitat—**Area: 17.8 ha. The southern habitat area is adjacent to Douglas Fluhrer Park and includes Anglin Bay, encompassing management units TC-4, TC-5 and TC-AB. Water within this area is relatively deep (approximately 2-6 m in areas of vessel draft) and contains fewer macrophyte beds due to marina vessel traffic.

4.3.2.3 Brown Bullhead Exposure Point Concentrations

Brown bullhead exposure point concentrations (EPCs) were developed using the surface sediment inverse-distance weighting technique presented in Section 3.1. PAH and PCB concentrations were calculated separately for each of the four candidate habitats. The 75th percentiles from the IDW surface were used to estimate EPCs.

The use of the 75th percentile for sediment EPCs for fish differs from the percentiles used for other receptors (e.g., calculations for the wildlife assessment use 90th percentiles, and the herptile assessment uses 95th percentiles). These differences are based, in part, on the level of uncertainty inherent in the estimation of exposure to organisms using sediment as the primary pathway of exposure. The greater the uncertainty, the higher the percentile adopted (i.e., greater conservatism is adopted in the face of increased uncertainty). For brown bullhead, the importance of sediment as a driver for exposure, uptake, and incidence of deformities is well understood and documented in the literature, and the foraging behaviours of bottom fish (including bullhead) are also well documented. The foraging behaviour of bullhead dictate that these organisms would be exposed to a weighted average of sediment contamination levels over a chronic exposure period rather than continuously exposed to extremes within any sediment management unit. The use of a 75th percentiles provides some conservatism over the use of a median or average concentration; this accounts for the possibility that some or most bullheads within each unit may preferentially use habitats that have higher than average concentrations of PAHs and/or PCBs. For example, because PAHs and PCBs tend to be higher in concentration near the shoreline, use of a 75th percentile would account for a scenario in which bullheads feed proportionally more in shoreline habitats.

4.3.3 Risk Characterization

Based on the home ranges presented in Section 4.3.2.2 and the deformity-based screening criteria presented in Section 4.3.2.1 for PCBs and PAHs it is possible to make inferences regarding the potential impacts to fish health in the KIH home ranges (**Table 5**).

Table 5: Surface Sediment PAH and PCB Concentrations and Associated Potential for Bottom Fish Deformities

Habitat Area	PAH (75th Percentile)	PCB[1] (75th Percentile)	Overall Risks to Fish Health (Deformities)
North	12.7	0.36	Moderate Risk
North-Central	4.52	0.63	Low to Moderate Risk
South-Central	5.23	0.62	Low to Moderate Risk
South	10.5	0.39	Moderate Risk

Shading of sediment concentrations	Below low-risk benchmark	Exceeds low-risk benchmark	Exceeds moderate-risk benchmark	Exceeds high-risk benchmark

1. As discussed in CLAW (2013), the evidence for causal linkages for low-level PCB exposures was weaker than for PAHs, and it is likely that elevated prevalence of lesions at sediment PCB concentrations below 1.0 mg/kg dw reflects co-occurrence with PAHs. However, PCBs were retained due to their potential to interact with other substances in a complex mixture.

The interpretations of the fish health assessment provided above have value for making broad statements regarding risks to fish in KIH. A narrative summary of these findings is provided below:

- **High Risks—**No management areas were identified as having high risk, although the EPC for the North fish habitat was close to the 15 mg/kg dw sediment PAH threshold for high risk. The North fish habitat corresponds most closely to the location of bullhead specimens sampled by RMC-ESG in 2009 (with elevated deformity incidence).
- **Moderate Risk—**Both the North and South fish habitats within KIH were identified as moderate risk areas based primarily concentrations of PAHs above the moderate risk threshold of 8 mg/kg, coupled with concentrations of PCBs marginally exceeding the low risk threshold of 0.3 mg/kg. The PAH-based risk levels are considered to be more reliable than the PCB-based risk levels due to the greater degree of mechanistic and empirical support for PAHs as a causal agent for deformities.
- **Low to Moderate Risks—**Both the north-central and south-central fish habitats were identified as low to moderate risk to bottom fish due to concentrations of PAHs slightly above the low risk threshold of 4 mg/kg, combined with PCBs marginally above the moderate risk threshold of 0.5 mg/kg.
- **Negligible Risks—**The remainder of KIH beyond the Western KIH, including TC-E and the Upstream Reference Zone, would classify as negligible risk to fish health as concentrations of PAHs and PCBs fall well below the low effects thresholds for both substances.

4.4 Conclusions

4.4.1 Magnitude of Risk

The evaluation of fish health in KIH indicates that the risk level is low for most fish species, with accumulations of contaminants into fish tissue remaining at or below concentration thresholds protective against survival, growth, reproduction, and developmental effects. However, bottom fish are an exception, particularly species such as brown bullhead, which have an intimate relationship to the sediment through diet and cold weather dormancy. The evidence from both field and literature evaluations indicates increased risk of health impairment due to increased prevalence of external and liver lesions. These risks are greatest in the northern and shoreline areas of KIH, where concentrations of PAHs in localized areas often exceed the high risk sediment PAH threshold. Although spatial averaging of exposure reduces PAH exposure to below the high risk threshold, it is possible that subpopulations of bullhead may be exposed to concentrations of PAHs that exceed the high risk threshold. For example, the average spatially-weighted concentration in three management areas (PC-W, TC-RC, and WM) exceeds the high risk PAH threshold of 15 mg/kg dw (**Table 2**). The overall risk level to bottom fish is moderate for significant portions of KIH sediment; this conclusion is supported by the field evidence of external abnormalities in the 2009 field program.

4.4.2 Uncertainties

The greatest uncertainties in this assessment relate to the foraging patterns of bullhead, the potential for interactions among multiple constituents (such as PAHs, PCBs, and metals in a chemical mixture), and questions regarding the ecological importance of lesions on fish. These factors are discussed below.

- **Foraging patterns**—Similar to the uncertainties of the benthic invertebrate community assessment, we cannot rule out the possibility that areas with elevated contamination have not been sampled. However, given the large number of samples and the distribution of sampling stations within KIH, the likelihood that areas of elevated contamination have not been detected is small. A greater uncertainty relates to the degree to which bullhead may be exposed to localized areas of elevated contamination, particularly for PAHs along the shoreline of PC-W, TC-RC, WM, and adjacent to Anglin Bay. These individual areas are probably small that the home ranges of most brown bullhead in KIH, but are sufficiently large that they would meaningfully influence the average exposure conditions. It is also uncertain how brown bullhead utilize the nearshore habitats relative to the sediments in the centre of KIH. The use of a 75th percentile offers some conservatism relative to an average or median concentration, although the selection of any specific percentile is based on professional judgement, and therefore uncertain.

- **Interactions among constituents**—the potential exists for interaction of chemical mixtures within the sediments resulting in additive and/or synergistic effects. Although the strongest evidence for causation of bullhead deformities is for PAHs, there is evidence in the literature of non-additive responses when PAHs are combined with other substances. Numerous studies of bottom fish deformities in Puget Sound have documented lesions associated with PAH contamination, but also co-occurrence with other industrial pollutants, including polychlorinated biphenyls (PCBs), pesticides, and heavy metals (Johnson et al. 2002, 2008). The occurrence of bottom fish lesions in these areas of multiple constituents is greater than in areas with PAH contamination in isolation, suggesting modifying effects of other contaminants on the toxicology of PAHs in fish. Gauthier et al. (2014) also document evidence for potential interactions between PAH and metal exposure, noting many similarities in the individual toxicities of metals and PAHs including ionoregulatory dysfunction and reactive oxygenated species imbalance. They note several proposed mechanisms that could be responsible for enhanced toxicity when PAHs and metals are simultaneously present: (1) elicitation of non-additive co-toxicity through cytochrome P450 inhibition; (2) role of reactive oxygenated species in metallothionein inhibition; (3) capacity for PAHs to increase metal bioavailability; (4) interactive effects among the former three mechanisms; (5) other potential mechanisms. The mechanisms that could explain the specific patterns of abnormalities in KIH bullhead are not well understood, particularly as individual mechanisms of toxicity vary by the specific metal, PCB congener, and/or PAH involved.

- **Ecological significance**—The biological consequences of external deformities such as lesions and ulcers, fin and tail erosion, and damaged barbels, are difficult to quantify. RMC-ESG (2014) has correctly documented that the presence of fish tumours and other deformities is considered a beneficial use impairment. However, presence is deformities in ecological risk assessments is usually considered to be of lower importance for population and community evaluation (relative to survival, growth, reproduction, and developmental endpoints) unless the abnormalities interfere with long term survivability or reproductive output. The environmental protection goal for deformity incidence has not been clearly defined, and as such, broader consultation may be needed to determine the importance/weight that should be assigned to this endpoint (for overall risk characterization and remediation planning). There is also some indication by RMC-ESG that the Cataraqui Stakeholder Group has offered an opinion on the importance of this risk pathway relative to protection of human health and wildlife.

In the face of these uncertainties, we have assumed that exceedance of the 8 mg/kg total PAH benchmark (i.e., based on an MATC derived from other studies of PAH contamination and bottom fish effects in Great Lakes studies) provides a suitability protective benchmark for KIH bullhead. This value is generally consistent with Baumann (2013), which indicates that a similar concentration (10 mg/kg total PAH) provides a sediment exposure level above which significantly elevated tumour rates are likely. As the field studies used to develop the PAH benchmark are from assessments of contaminated harbours, each with multiple contaminants, the benchmark is inclusive of some of the potential interactive effects. It remains uncertain whether the potential interactions in KIH are greater, lesser, or comparable to other Great Lakes sites.

5.0 WILDLIFE RISK ASSESSMENT

In this document, the term "wildlife" refers to birds and mammals present within KIH, including herbivorous and piscivorous mammals, and non-piscivorous, piscivorous, and omnivorous birds.

5.1 Methods

The wildlife risk assessment provided by RMC-ESG (2014) generally follows widely accepted ecological risk assessment approaches and provides a useful screening of the wildlife risk pathways of greatest significance to KIH. The risk refinement therefore focussed on addressing issues raised by FCSAP Expert Support, particularly where the issues had implications for the overall risk conclusions.

The major themes identified by Expert Support in relation to the wildlife ERA components were:

- Modelled receptor species—Several Expert Support comments pertained to the lack of formal assessment of species identified as receptors of concern, but that were not modelled or evaluated quantitatively. For example, muskrat and red wing blackbird were suggested as candidate species for an assessment of semi-aquatic species.
- Characterize ecological effects in spatially explicit manner—several Expert Support comments emphasized the need to consider wildlife risk outcomes more clearly linked to subunits of KIH, with clearer linkages to receptor foraging areas.
- Exposure assumptions for wildlife—Some Expert Support comments focussed on specific parameter choices, such as dietary assumptions for mink and mallard, or other technical approaches that influence hazard quotients. In the review of the draft risk synthesis, Expert Support also requested clarification on why the selected percentiles from the IDW surfaces of sediment contamination differ from other receptor types (e.g., fish).
- Screening-level versus detailed-level evaluations—Some Expert Support comments requested clarification regarding whether risk characterization findings were based on conservative (screening-level) risk estimates or alternatively were based on more refined or site-specific risk estimates.

The risk refinement addressed these issues by repeating the RMC-ESG (2014) food web model calculations, but adjusting exposure estimates and model parameters as necessary to address factors that meaningfully influenced risk assessment outcomes. The first step entailed replicating the RMC-ESG hazard quotient calculations, using the model inputs, equations, and assumptions as documented in Chapter IV of RMC-ESG (2014). This provided confirmation of the original calculations prior to making adjustments. A few discrepancies were observed at this stage; however, the differences were not substantive (i.e., were numerically minor or did not affect the identification of species/contaminant combinations with hazard quotients close to one). As there are several explanations for minor discrepancies (e.g., subtle differences in processing of exposure data, such as wet weight/dry weight conversions, or rounding errors) the spreadsheet models were therefore considered to be sufficiently reliable to make the adjustments requested by Expert Support.

5.1.1 Species Selection

RMC-ESG did not choose threatened or endangered species in the selection of organisms for the food web model. This is not inherently problematic, as it is common in ecological risk assessment to select surrogate species to represent groups of similar organisms, particularly those at similar feeding levels. Use of surrogate organisms allows for models to adopt exposure profiles for well-studied species, under the assumption that results can be extrapolated to other wildlife in similar feeding guilds. The wildlife species at risk identified by RMC-ESG include the loggerhead shrike *Lanius ludovicianus* (Endangered), the king rail *Rallus elegans* (Endangered), the least bittern *Ixobrychus exilis* (Threatened), the common nighthawk *Chordeiles minor* (Threatened), the chimney swift *Chaetura pelagica* (Threatened), the red-headed woodpecker *Melanerpes erythrocephalus* (Threatened), the short-eared owl *Asio flammeus* (Special concer) and the black tern *Chlidonias niger* (Special Concern). These species are reasonably represented by the mallard, great blue heron, osprey, and red-winged blackbird, which were selected by RMC-ESG as receptors of concern. The methods used for the wildlife assessment (i.e., evaluation of potential individual level responses by comparing doses to conservative effects-based benchmarks) are also suitable for the evaluation of threatened or endangered species.

Two specific issues were raised by Expert Support regarding identification of sensitive species:

- Exclusion of herbivorous animals—Herbivorous animals (mammal: muskrat; bird: red-winged blackbird) were included in the conceptual site model as sensitive species of potential concern. However, RMC-ESG (2014) excluded these organisms from the food web modelling "because their habitat is limited to the Orchard Street Marsh, whose individual assessment is outside the scope of the present ERA." We can appreciate that quantifying risks is challenging for species that primarily occupy the upland portions of the Orchard Street Marsh (i.e., upgradient of the federal lot boundaries as shown in **Figure 2**). However, given that these herbivorous animals would potentially integrate their exposures across <u>both</u> the Orchard Street Marsh and the riparian areas of the federal water lots (e.g., adjacent to the unnamed Creek in management unit PC-W), some type of quantitative evaluation is necessary, at least for screening purposes. Therefore, to address the Expert Support request, we included an omnivorous bird and an herbivorous mammal in our food web model revisions, under the conservative and simplified assumption that exposures within the federal water lots (alone) reflect the overall exposure profile to those species.

- Ecological relevance of mink—Expert Support expressed concerns regarding the RMC-ESG statement that “although mink are confirmed to be present in the harbour, there is limited suitable habitat and it may not be appropriate to determine sediment management scenarios based on potential risks to mink.” Our understanding is that the RMC-ESG comment is intended to communicate the lower quality and area of mink habitat south of the former Belle Landfill, relative to productive upstream areas such as the Great Cataraqui Marsh. To address this issue, we have retained mink in the food-web model, but have assumed that mink habitat occurs only in the management areas immediately adjacent to the undeveloped vegetated shorelines in KIH (i.e., management areas PC-E, PC-W, and TC-OM). Areas in the central KIH or the developed areas along the western shoreline would not support mink habitat of sufficient quality to provide a meaningful contribution to overall exposure.

Although herbivorous animals were included in the risk refinement, we adopted an alternate selection of an avian marsh inhabitant to the red-winged blackbird; we instead selected the marsh wren *Cistothorus palustris* for inclusion in the food web model. The rationale for this selection was:

- Standardized receptor information was available for marsh wren (US EPA 1993) that was not available for blackbirds, thus facilitating the application of the food web model;
- Marsh wrens were considered to be equally site-relevant to blackbirds in terms of representing marsh-like exposures. Territories of both red-winged blackbirds and marsh wrens are commonly associated with wetland habitats, such as cattail marshes. Furthermore, Red-winged blackbirds, marsh wrens, and swamp sparrows were all reported nesting in the Orchard Street Marsh south of Belle Park (Ecological Services 2008);
- Marsh wrens have small foraging ranges, resulting in a conservative assessment of risk in the marsh-like areas within and adjacent to the federal water lots; and
- Limitations to available data (e.g., insect exposure data) should apply equally to marsh wrens and red-winged blackbirds, as both consume a combination of seeds and insects, with insect diet increasing during the reproductive season for both species.

The muskrat *Ondatra zibethicus* was also included at the request of Expert Support, and provides an assessment of risk to semi-aquatic mammals with a non-fish diet.

In conducting the food-web modelling for marsh wren and muskrat, we acknowledge that the uncertainty is greater for these receptors relative to other modelled species. The hazard quotients reflect high uncertainty in the dietary concentration inputs, and simplistic assumptions regarding exposure averaging areas. The contribution of upland exposures to these species has not been assessed in this document, as the contributions of non-federal properties are beyond the scope of this assessment.

5.1.2 Exposure Doses and Home Ranges

One of the most significant comments from Expert Support related to exposure averaging (i.e., the definition of water lot areas for which each receptor can be assumed to forage across). Environment Canada commented that "the reduction of the overall average through removing hotspot may still leave receptors having specialized or small home ranges with unacceptable concentrations available to them." We recognize that RMC-ESG (2014) considered foraging ranges to some degree in the calculation of the sediment quality objectives for mink and mallard; however, the technical linkage between the foraging ranges documented in the literature and those applied in the risk assessment was not always clear. To address this issue, we determined the home ranges of relevance to each wildlife receptor and have assigned receptor habitats to specific management units (or combinations of units, as applicable) to provide a spatially explicit representation of risk.

- **Mink**—RMC-ESG (2014) considered the information on mink home ranges, and concluded that because "the length of shoreline within the APEC is a minimum of 2.0 km, and the recommended home range with well within the KIH, it is conservatively estimated that mink inhabiting this area will harvest 100 percent of their diet from the APEC." Although the spatial domain of the APEC was not defined in detail, the area considered by RMC-ESG (2014) is apparently larger than the lower end of the home ranges documented in the literature, including the FCSAP default home range values of 0.06 km^2 (6 ha) or 0.4 km in length (Environment Canada 2012). As such, while the APEC may be a realistic depiction of mink home ranges for the conditions present in KIH, it cannot be deemed conservative, at least in relation to the FCSAP default parameter. To address this issue, we identified exposure areas for mink that are closer to the FCSAP guidance, and that represent areas of habitat that would be conducive to utilization by mink. The only three management units that provide reasonable quality mink habitat are PC-E, PC-W, and TC-OM. Other areas in KIH are considered too distant from preferred mink habitats to contribute substantively to exposure. In terms of home ranges, PC-E has an area of approximately 9.5 ha and a linear range of approximately 0.5 km of shoreline. The combination of management units PC-W and TC-OM has an area of approximately 9.7 ha and a linear range of approximately 1.0 km of shoreline. Accordingly, two discrete and non-overlapping areas of mink habitat were identified that fall near the lower end of the range of foraging areas for this species. Use of the lower end of the documented range was considered appropriate because the smallest foraging range sizes were determined from adult females (i.e., applicable to the reproductive period of greatest relevance to risk assessment), and provide a conservative assessment consistent with FCSAP guidance. The areal ranges of approximately 10 ha also fall within the range of 7.8 to 20.4 ha for females reported by Mitchell (1961) as documented by US EPA (1993).

- **Muskrat**—Relative to most semi-aquatic mammals, muskrats have relatively small home ranges (Perry 1982, Willner et al. 1980). Using radiotelemetry, MacArthur (1978) documented that muskrats rarely forage more than 150 m from their primary dwelling. Proulx and Gilbert (1983) also documented that muskrats in Ontario marshes usually spend most of their time within several tens of metres of their den, with areal home ranges estimated to be 0.17 ha in the summer. Therefore, the individual home ranges of muskrat are smaller than the individual management units shown in **Figure 2**. The only three management units that provide reasonable quality muskrat habitat are PC-E, PC-W, and TC-OM.

- **Mallard**—The FCSAP default home range value is 9.2 ha (Environment Canada 2012), although it is recognized that mallards exhibit a range of foraging behaviours depending on habitat and availability of food resources. Furthermore, the value of 9.2 ha is conservative, as Dwyer et al. (1979) report home ranges varying from 111 to 468 ha. For the revised food web model, the management zones were grouped into areas close to the default home range value where habitat quality is best (i.e., the undeveloped and vegetated areas of KIH) with larger areas (i.e., up to 30 ha) for more marginal habitats. The entire Western KIH was retained as potential mallard habitat.

- **Marsh Wren**—US EPA (1993) summarizes the habitat requirements and foraging ranges of marsh wrens; they inhabit freshwater marshes, usually nesting in association with bulrushes, cattails, and sedges in water depths from several centimeters to nearly a meter. Average territory size for a given year and location are variable, but are generally small (typically less than 0.2 ha). Therefore, the individual home ranges of muskrat are smaller than the individual management units shown in **Figure 2**. The only three management units that provide reasonable quality marsh wren habitat are PC-E, PC-W, and TC-OM, and of these units PC-W is by far the most suitable habitat for marsh wrens.

- **Heron**—The home range of the great blue heron is variable and dependent on the local availability of food (US EPA 1993). A default FCSAP value is 16.6 km^2 (1660 ha) is given with linear foraging distances ranging from 2.3 km to 30 km (Environment Canada 2012). Mathisen and Richards (1978) reported the distance between heronries and possible feeding areas in Minnesota lakes to range from 0 to 4.2 km, averaging 1.8 km. Based on this information the entire Western KIH (i.e., summation of all individual management units except TC-E and PC-N) appears to be an appropriate foraging range for great blue herons.

  Osprey— The distance osprey travel from their nests to forage depends on the availability of appropriate nest sites near areas with sufficient fish, with individual travelling up to 10 to 15 km to obtain food (Van Daele and Van Daele 1982). At sites with good access to prey, foraging distances are smaller, with the smallest ranges reported by US EPA (1993) from a study from Dunstan (1973), which cites a range of foraging distances between 0.7 -2.7 kilometres for a Minnesota lake environment. Based on this information the entire Western KIH (i.e., summation of all individual management units except TC-E and PC-N) appears to be an appropriate foraging range for osprey.

Once the exposure areas were defined, it was necessary to adjust the exposure point concentrations (EPCs) used by RMC-ESG (i.e., the Table IV-25 entries from Chapter IV of RMC-ESG 2014) to new EPCs that reflect the updated exposure assessment. This was conducted using the following steps:

- Sediment concentration surfaces were created using the ArcGIS Version 10.3.1 inverse-distance weighting (IDW) procedure.
- Grids (5 × 5 m cells) corresponding to the home ranges defined for each receptor above (i.e., combination of management units) were filtered. Organism with larger home ranges had a large number of grid cells carried forward.
- EPCs for sediment exposure were calculated using the 90^{th} percentiles of the filtered IDW surface. The purpose of the 90^{th} percentile is to avoid underestimation of exposure, such would occur if receptors had a preference for foraging over more contaminated portions of the exposure unit. The use of the 90^{th} percentile for wildlife, rather than the 75^{th} percentile used for bullhead EPCs, relates to the increased uncertainty in the estimation of wildlife exposures using a dose-based trophic transfer model. Several of the inputs in the food-web model convey high uncertainty due to the paucity of information on site-specific bioaccumulation (e.g., sediment to tissue BSAFs or BAFs for the main dietary items of each species). Furthermore, the relative contributions of terrestrial versus aquatic prey items are less well understood relative to fish, and the home range information for wildlife species was more variable than for bullhead. Use of a higher percentile provides a more conservative exposure estimate in the face of this increased uncertainty.
- The RMC-ESG (2014) model used the 95% upper confidence limit of the mean value (95UCL) from individual sample points. The switch from a UCL to a percentile-based approach in the risk refinement reflects the change from a population of discrete concentration measurements to a smoothed IDW surface.
- The EPC values (mg/kg) of remaining media were prorated using the fish, water, macrophyte and invertebrate data compiled by RMC-ESG (2014; Table IV-25). This approach assumed that the EPCs derived by RMC-ESG were appropriately representative of the APEC, but also assumed that smaller units (management areas) would have variations in average tissue concentrations that are approximately proportional to the differences in sediment concentrations among management units. Accordingly, the EPCs were adjusted

upward for more contaminated portions of the water lots, and adjusted downward for less contaminated areas.

The sediment EPCs used in the above procedure are summarized by COPC and management unit in **Appendix B – Table B1**.

5.1.3 Toxicity Reference Values

In RMC-ESG (2014), the primary basis for the hazard quotients for wildlife are comparisons to TRVs developed using the US EPA Eco-SSLs. The Eco-SSL derivation method considers a high quantity of information for relevant toxicogical studies, and identifies screening levels for mammals and birds intended to provide adequate protection of terrestrial and aquatic ecosystems. Eco-SSLs are derived in a manner that is protective of the conservative end of the exposure and effects species distribution, and the TRVs for wildlife are intended to be applied at the screening stage of an ecological risk assessment (US EPA 2008). US EPA specifically warns that Eco-SSLs are "not designed to be used as cleanup levels" by rather to identify the contaminants of potential concern (COPCs) that require further evaluation.

Accordingly, hazard quotients lower than 1.0 using Eco-SSL based TRVs, particularly when combined with other conservative screening assumptions, can be confidently assumed to convey negligible risk. Where hazard quotients exceed 1.0, additional evaluation of the underlying toxicological data are warranted. Allard et al. (2009) summarizes emerging guidance for the selection of TRVs, emphasizing an effect-size based approach from multiple studies rather than point estimate TRVs based on NOAELs and LOAELs from single studies. A similar recommendation is made in Environment Canada's ecological risk assessment guidance for federal contaminated sites. Golder (2012) applies these principles in the development of TRVs for chromium and polychlorinated biphenyls (PCBs), with separate values developed for birds and mammals.

In the risk refinement, the following revisions were made to the use of TRVs in the wildlife ecological risk assessment:

- Negligible Risk—Lack of exceedance of the TRV based on Eco-SSL derivation (i.e., geometric mean of all no-observed adverse effect level results for growth and reproduction are used to calculate a geometric mean NOAEL).
- Low Risk—Exceedance of the TRV based on Eco-SSL derivation.
- Moderate Risk— Exceedance of the TRV based on the lower TRV from Golder (2012).
- High Risk— Exceedance of the upper TRV from Golder (2012).

5.1.4 Dietary Patterns

Expert Support raised some questions with respect to the sensitivity of the food web model in the parameterization of dietary composition for wildlife. Specifically:

- Food ingestion for mink in the RMC-ESG evaluation assumed a diet comprised of 100% fish as opposed to 30% as indicated in FCSAP guidance (Environment Canada 2012).
- Hazard quotients for the mallard duck were calculated assuming 100% benthic invertebrate diet for some COPCs, whereas 100% macrophyte diet was assumed for other COPCs. Because dabbling ducks are feed on aquatic plants (50%), aquatic invertebrates (40%), and other minor components (berries, seeds, insects

and fish) (Environment Canada 20120 Expert Support queried whether these estimates are preferred to an assumption of a blended diet, which better matches the federal default guidance.

With respect to the assumed dietary composition, RMC-ESG (2014) acknowledged that the mink's diet is suggested to be 30% fish (with Environment Canada indicating that remaining diet consists of crustaceans [25%], small mammals/birds [25%], amphibians [10%], and insects [10%]). As mink are highly opportunistic, the actual dietary assemblage is highly variable by site, reflecting the availability of various items. The rationale used by RMC-ESG for use of 100% fish in diet was not an assumption that KIH mink actually consume only fish, but rather concern about the uncertainty of estimates for the remaining dietary components. Evaluation of the sensitivity of risk calculations to this assumption entails several considerations:

- Invertebrate diet—The proportion of invertebrates in mink diet is variable depending on availability of resources. Crayfish are a popular dietary item when present, due to their size and relative ease of capture. Unfortunately, little is known regarding the degree of prey switching that occurs in KIH mink. The concentrations of other dietary items (mammals, birds, herptiles) relative to invertebrates are also unknown.
- Ratio between fish and invertebrate concentrations—The only substance for which hazard quotients above 1.0 were calculated was total PCBs. Due to the biomagnifying property of PCBs, concentrations in fish are typically greater than those in benthic invertebrates. However, the size class of fish and type of invertebrate consumed affects the magnitude of this difference. Juveniles and smaller fish tend to exhibit lower PCB concentrations relative to older and larger specimens (Weston 2004). The difference between PCBs concentrations in small to medium sized fish (likely to be consumed by mink) and the corresponding concentrations in invertebrates is likely to be less than a factor 2 (based on literature, mechanistic models, and site data from PCB contaminated aquatic sites).
- Site fidelity of prey items—If non-fish items provide the majority of dietary content of KIH mink, an important consideration is whether the alternative dietary items are exposed to PCB in sediment within smaller averaging areas than would be relevant to fish. Because maximum PCB concentrations are observed in shoreline locations (e.g., PC-W adjacent to former Belle Landfill), it is possible that these locations could yield higher tissue concentrations than invertebrates, when compared to fish that forage over larger areas.
- Model estimates—If non-fish food items are to be considered in the food web model for mink, estimation of invertebrate concentrations rely on model estimates (n.b., trophic transfer modeling was carried out by RMC-ESG to estimate concentrations of PCBs, DDT, chlordane, and PAHs). The estimate of invertebrate PCB concentration developed by RMC-ESG, which was obtained using a regression equation between sediment and invertebrate uptake from the literature, was approximately 45% of the fish tissue exposure point concentration.

To evaluate the sensitivity of the dietary composition assumption, the model was rerun with the dietary preferences set to 30% fish and 70% invertebrates. The hazard quotients in the revised model were lower than the original estimates (e.g., highest HQ of 1.92 dropped to 1.13). This indicates that there may be some additional conservatism in the use of the 100% fish diet, although the magnitude of difference is not large, especially when viewed in conjunction with other uncertainties. The original RMC-ESG parameterization was retained for the simulations provided in Appendix B.

With respect to mallard dietary composition, it is true that mallards are omnivorous (particularly females during reproductive season) and consume a blended diet of macrophytes, algae, and various invertebrate items.

However, similar to the mink diet issue discussed above, the RMC-ESG analysis was constrained by data availability. Different proportions of dietary items were assumed for different COPCs, based on the site-specific data availability for contaminant concentrations in food items. For chromium, only invertebrate data were used by RMC-ESG to obtain the most conservative estimate of dose, whereas for other metals (arsenic, copper, lead, zinc) only macrophyte data were used. The selections made by RMC-ESG are based on the principles that: (1) site-specific tissue data, when available, provide a superior estimate relative to model estimates (e.g., application of bioaccumulation or bioconcentration factors), and (2) conservatism is preferred in the face of high uncertainty.

Although the rationale set forth by RMC-ESG (2014) has merit, the assumption of 100% invertebrate diet is more questionable for substances that have macrophyte data available. Tissue data for sixteen macrophyte samples were available for chromium, seven macrophyte samples for antimony, and three macrophyte samples for PAHs. Although these data are limited, use of these data is considered preferable to an assumption of 100% invertebrate diet. Accordingly, the original RMC-ESG parameterization was revised for these three substances, splitting diet evenly between macrophytes and invertebrates for these three constituents (Appendix B). Substances for which no macrophyte data are available (e.g., PCBs) retained the original RMC-ESG parameterization because modelling of macrophyte concentrations would be highly uncertain.

5.2 Results

The results of the updated food web modelling are provided in **Appendix B**. For each receptor, a table is provided showing the calculations with the original RMC-ESG parameterization. For example, **Table B-2a** presents the calculations for mink using the RMC-ESG Table IV-25 parameters and associated hazard quotient derivations for the entire APEC. Subsequent tables provide the adjusted model estimates once changes are made to reflect the updated discussed in Section 5.1, with a separate table for each exposure area relevant to the receptor.

Table 6 provides a summary of the overall findings for all wildlife. The hazard quotients above 1.0 were mainly observed for PCBs and chromium, although some marginal exceedances for lead (HQ < 2) were derived for marsh wren.

Table 6: Areas and Management Units Considered in the Risk Refinement

<table>
<tr><th rowspan="2">Individual Management Units</th><th rowspan="2">Area (ha)</th><th colspan="3">Mink</th><th colspan="3">Muskrat</th><th colspan="3">Mallard</th><th colspan="3">Marsh Wren</th><th colspan="3">Heron</th><th colspan="3">Osprey</th></tr>
<tr><th>PCB</th><th>Cr</th><th>Other</th><th>PCB</th><th>Cr</th><th>Other</th><th>PCB</th><th>Cr</th><th>Other</th><th>PCB</th><th>Cr</th><th>Other</th><th>PCB</th><th>Cr</th><th>Other</th><th>PCB</th><th>Cr</th><th>Other</th></tr>
<tr><td>PC-E</td><td>9.5</td><td><1.0</td><td><1.0</td><td><1.0</td><td><1.0</td><td>1.8</td><td><1.0</td><td><1.0</td><td>1.0</td><td><1.0</td><td></td><td>3.4</td><td>1.1</td><td rowspan="13"><1.0</td><td rowspan="13"><1.0</td><td rowspan="13"><1.0</td><td rowspan="13"><1.0</td><td rowspan="13"><1.0</td><td rowspan="13"><1.0</td></tr>
<tr><td>PC-W</td><td>7.3</td><td rowspan="2">1.2</td><td rowspan="2"><1.0</td><td rowspan="2"><1.0</td><td><1.0</td><td>5.6</td><td><1.0</td><td rowspan="2"><1.0</td><td rowspan="2">2.2</td><td rowspan="2"><1.0</td><td>1.3</td><td>14.5</td><td>1.6</td></tr>
<tr><td>TC-OM</td><td>2.6</td><td><1.0</td><td>2.2</td><td><1.0</td><td></td><td>4.5</td><td>1.2</td></tr>
<tr><td>TC-RC</td><td>3.6</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td rowspan="2"><1.0</td><td rowspan="2">1.0</td><td rowspan="2"><1.0</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>TC-1</td><td>26.1</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>WM</td><td>1.9</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td rowspan="3"><1.0</td><td rowspan="3"><1.0</td><td rowspan="3"><1.0</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>TC-2A</td><td>5.1</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>TC-2B</td><td>8.2</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>TC-3A</td><td>4.1</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td rowspan="3"><1.0</td><td rowspan="3"><1.0</td><td rowspan="3"><1.0</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>TC-3B</td><td>3.1</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>TC-4</td><td>4.2</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>TC-5</td><td>9.2</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td rowspan="2"><1.0</td><td rowspan="2"><1.0</td><td rowspan="2"><1.0</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>TC-AB</td><td>4.4</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
</table>

Negligible Risk		All HQ values below 1.0 using screening level TRVs
Low Risk		HQ values above 1.0 but only using Eco-SSL screening TRV (exceedance of Eco-SSL shown as value in cell)
Moderate Risk		HQ values below 1.0 using Golder (2012) lower-bound TRV (exceedance of lower-bound TRV shown as value in cell)
High Risk		HQ values below 1.0 using Golder (2012) upper-bound TRV
Not Applicable	-	Suitable habitat for receptor not present within management area (no HQs calculated)

5.3 Conclusions

5.3.1 Comparison to RMC-ESG Estimates

As with the original RMC-ESG analysis, risks to herons and osprey are negligible. The RMC-ESG (2014) wildlife risk assessment derived hazard quotients above 1.0 for only two COPCs:

- PCB exposures to mink in the APEC yielded a hazard quotient of 1.6 compared to the most conservative TRV, and a hazard quotient of 1.1 compared to the lower TRV from Golder (2012b).
- Chromium exposures to mallard ducks in the APEC yielded a hazard quotient of 2.3 compared to the most conservative TRV, and a hazard quotient of 1.2 compared to the lower TRV from Golder (2012b).

Both of these findings result in a moderate risk (yellow) determination following the categorization discussed in Section 5.1.3 and applied in **Table 6**.

Considering the number of changes made to the models, the results of **Table 6** are similar to the original RMC-ESG conclusions, with moderate risk to mink and mallard under both evaluations. The main difference is that the risk determinations have now been made more spatially explicit, with the moderate risk to these species confined to the portion of KIH nearest the Orchard Street Marsh (PC-W and TC-OM units combined). In adjacent portions of KIH, the risks to mink and mallard are either negligible, or marginally exceed HQ=1.0 (and only for the most conservative TRV).

The most notable difference relative to RMC-ESG (2014) relates to the identification of non-negligible risks to marsh wren (moderate risk) and muskrat (low risk). These calculated risks were greatest in the PC-W management unit, where localized elevations of chromium, PCBs, and lead are observed. The risks to these species are driven by a combination of small home ranges and high normalized food ingestion rates relative to other species such as the mallard. As indicated earlier, the uncertainty in the risk estimates for marsh wren and muskrat is greater than for mallard due to the highly simplified exposure assumptions required for the former. However, the analysis indicates that other omnivorous birds and mammals in the wetland area would have risks that are greater than those of mallards, which were previously identified as the most sensitive species to chromium contamination in KIH.

5.3.2 Key Uncertainties

The greatest uncertainties in the wildlife risk assessment relate to the contribution of upland (soil) exposures to risk, uncertainty in the chromium TRV, and uncertainty in the tissue concentrations of dietary items of omnivores (plant and invertebrate tissue). These factors are discussed below.

- **Upland Exposures**—The scope of the assessment is constrained to the water lots under the jurisdiction of the federal custodians. Therefore, although habitat for birds and mammals exist on the upland portions of the harbour (e.g., Orchard Street marsh soils), the purpose of this risk assessment is only to evaluate receptors with exposures overlapping the water lot sediments. Nevertheless, some semi-aquatic wildlife (e.g., marsh wren, muskrat) would have organisms that overlap the marsh-like habitats within both the federal water lots and adjacent parcels of Orchard Street marsh. Within the project scope, we have made the assumption that a small number of marsh wrens and muskrat could be exposed primarily to marsh habitats within the federal water lots.

- **Chromium TRV**—The various TRVs derived for chromium exhibit considerable variation (e.g., 38-fold difference between the low risk benchmark and the high risk benchmark for birds) reflecting the underlying variation and uncertainty in wildlife toxicity thresholds for chromium. For birds, the chromium dose-response analysis for all bird species and test endpoints combined (Golder 2012b) indicated few effects estimates greater than 10%, and as a result, a reliable dose-response relationship for the 10%, 20% and 50% effect levels could not be established. Therefore, the distribution of data did not allow for fitting of a reliable statistical model and therefore an IC_X-based TRV could not be derived.

- **Estimation of dietary concentrations**—The concentrations of COPCs in sediment and fish tissue are known with relative confidence, whereas other concentrations have uncertainty associated with the paucity of site-specific data. Although concentrations of some COPCs in macrophytes and invertebrates have been quantified, modelling or extrapolation from other media was required for several COPCs. This affects the confidence in the modelling of doses for omnivorous biota.

6.0 HERPTILES

In the review of the RMC-ESG (2014) deliverable package, Expert Support noted that, although reptiles and amphibians were included in the Conceptual Site Model (CSM), they were not included in the final risk assessment. RMC-ESG cited the paucity of relevant toxicological information for herptiles as the main reason for their exclusion from the formal characterization of risk.

At the outset, we must acknowledge that the assessment of herptiles is challenging for the KIH site given the lack of site-specific toxicity data, the limitations to literature-based toxicological information, and the complexity of the exposures of these animals (i.e., combination of aquatic and terrestrial exposure that is linked strong to life stage). However, in spite of these limitations, there are some opportunities for conveying potential risks to herptiles, at least for some of the COPCs at the site.

Our approach is based on the following assumptions:

- The primary pathway of interest is through contact with sediment-associated COPCs. Whereas amphibian exposure by definition would include water and sediment exposures, plus food items linked to both water and sediment, the screening of site data has indicated that water-based exposure pathways are less of a concern relative to sediment. RMC-ESG (2004; Table I-7) summarizes the water quality screening from historical studies; these studies indicated that the KIH, although eutrophic in condition, exhibits generally good water quality in relation to provincial and federal guidelines, which are considered to be protective of all organism types.
- The uncertainty in bioaccumulation of sediment-associated COPCs to amphibians is greater than that of other receptor groups, including wildlife. Because herptiles have complex life histories often linked to both aquatic and terrestrial habitats, with exposures a function of species, habitat type, and developmental stage, estimating the risk associated with sediment contamination is highly uncertain.
- Field studies from other sites are potentially useful for evaluating herptiles; however, the applicability of the results is constrained by the similarity (or thereof) of the contaminant profiles for the respective sites.
- RMC-ESG conducted a recent review of the literature and ecotoxicological databases and confirmed that development of reliable dose-based TRVs for amphibians or reptiles was not possible. Therefore, ecological assessment based on the concentrations of COPCs in sediment is the preferred approach to evaluating potential for harm.
- Laboratory toxicity studies conducted using sediment samples amended with concentrations of specific COPCs are of use for evaluating the sensitivity of herptiles to these constituents. Such studies are limited in terms of species representation and number of COPCs investigated, however.
- The scope of the assessment is constrained to the water lots under the jurisdiction of the federal custodians. Therefore, although habitat for reptiles and amphibians may exist on the upland portions of the harbour (e.g., Orchard Street marsh soils), the purpose of this risk assessment is only to evaluate receptors with exposures overlapping the water lot sediments. Accordingly, risks associated with soil-driven pathways linked to upgradient brownfields will not be considered as part of the risk refinement.

6.1 Species of Concern

RMC-ESG (2014) documented sixteen species of reptiles and amphibians that have been observed in the Lower Cataraqui River. Of five turtle species identified, three are listed as rare including the northern map turtle (*Graptemys geographica*: special concern), the stinkpot turtle (*Sternotherus odoratus*: threatened) and the Blanding's turtle (*Emydoidea blandingii*: threatened). The eastern milk snake (*Lampropeltis triangulum triangulum*) was also recorded upland areas adjacent to the harbour, and is listed as a species of special concern. It is not known whether these Species at Risk would be applicable to the KIH, given the limitations to habitat relative to Great Cataraqui Marsh, which is of greater area and quality of habitat given its designation as a provincially significant wetland. RMC-ESG notes that "the species list of reptiles and amphibians for the KIH is probably not complete, as it is based on observations made while carrying out other studies" but confirm that species richness for herptiles appear to be greatest near Great Cataraqui Marsh.

Biological surveys within KIH, particularly those characterizing the Orchard Street Marsh south of Belle Park, have documented several herptiles including midland painted turtles (*Chrysemys picta marginata*), common snapping turtles (*Chelydra serpentina*), leopard frogs (*Lithobates pipiens*, formerly *Rana pipiens*), bullfrogs (*Rana catesbeiana*) and green frogs (*Rana clamitans*), although their numbers and the overall amphibian species richness were extremely low (Ecological Services 2008). Map turtles and stinkpot turtles have been observed in the water lot south of Belle Park (Ecological Services 2008), and recent visits by Expert Support staff to the KIH confirmed presence of multiple turtle species.

6.2 Results from Spiked Sediment Tests

ENSR (2004) reports result from an Amphibian Toxicological Testing Program (Y0817 program) in which the United States Navy initiated a standardized approach to evaluate the potential toxicity of sediments or hydric soils to amphibians. Specifically, they evaluated the toxicity of four metals (cadmium, copper, lead, and zinc) to larval amphibians exposed to sediment in the laboratory, which resulted in a set of no observed effect concentrations (NOECs) and low observed effect concentrations (LOECs) LOECs) for lethal and sub-lethal endpoints. Studies were conducted with two species of amphibians, the American toad (*Bufo americanus*) and leopard frog (*L. pipiens*). Both of species are considered relevant to the assessment of sediment toxicity in KIH, particularly the leopard frog which has been observed on site.

To assess the significance of these findings, 95th percentile concentrations of COPCs from the smoothed IDW surface were screened against the NOECs and LOECs. The use of 95th percentiles, as opposed to lower percentiles used for wildlife and fish, stems from the uncertainty associated with the complex life histories of herptiles and their variable and complex linkages to sediment contamination. Sediment concentrations below the laboratory–derived NOECs are "unlikely to cause harm to the local amphibian population" whereas exceedances of NOECs may require additional investigation (ENSR 2004). Exceedances of the LOECs convey an elevated risk of sediment toxicity to amphibians.

- Copper—The 95th percentile copper concentration from the PC-W management unit is 110 mg/kg dw. This concentration falls within the range of unbounded NOECs for *L. pipiens* (64 to 200 mg/kg dw) and is below the NOEC for *B. americanus*. Other KIH management units with amphibian habitat have 95th percentile copper concentrations below the unbounded NOECs for both species.

- Lead—The 95th percentile lead concentration from the PC-W management unit is 437 mg/kg dw. This concentration falls below the unbounded NOECs for *L. pipiens* and *B. americanus* (2000 to 2400 mg/kg dw). Other KIH management units with amphibian habitat have lower lead concentrations relative to PC-W.
- Zinc—The 95th percentile zinc concentration from the PC-W management unit is 426 mg/kg dw. This concentration falls below the unbounded NOECs for *L. pipiens* and *B. americanus* (900 to 1200 mg/kg dw). Other KIH management units with amphibian habitat have lower zinc concentrations relative to PC-W.
- Cadmium—No IDW surface was available for this constituent. However, previous profiling of cadmium sediment chemistry distributions indicated that the vast majority of cadmium concentration in KIH are below 2.4 mg/kg, with extensive areas above 1.0 mg/kg adjacent to marsh-like areas that support amphibians. These concentrations are well below the LOECs for the two test species (110 – 580 mg/kg dw), but higher than the concentrations in the control treatment (0.32 – 0.46 mg/kg), which served as a NOEC.

The above metals exhibit elevated concentrations in KIH sediments adjacent to the marsh habitats, relative to other areas of KIH. However, the concentrations of these substances did not exceed effects concentrations (LOECs) and often were below associated NOECs, indicating lack of evidence for harm at these exposure concentrations. These metals represent only a subset of the COPCs for KIH, and the results do not account for potential mixture effects, but nevertheless are useful for consideration.

6.3 Extrapolation from Field Studies

6.3.1 Housatonic River PCB Site

Weston (2004) documents the results of a major investigation into the ecological effects of PCBs to freshwater aquatic life, including one of the largest site-specific investigations of responses to amphibians ever conducted. The study included a range of long term chronic toxicity testing using leopard frogs and wood frogs, including tests of various development stages. The study also included ecological assessment of numerous vernal pools, tissue concentration evaluation, population modelling, and other field investigations of amphibian community responses. Following the discrete analysis of biologically sensitive endpoints, model results were used to calculate threshold concentrations in environmental and biological media below which risks were deemed “acceptable,” or the probability of risk was deemed low. The maximum acceptable threshold concentration (MATC) was selected as the best estimate that provided protection of local amphibian populations.

The MATC for the project was based on the integration of the two most sensitive endpoints (metamorph malformation and sex ratios). The most compelling evidence for ecological degradation in the study was obtained from the sediment toxicity tests, which exhibited significant toxicological effects in both frog species, and exhibited a correlation between level of effect and sediment total PCB concentration. A sediment MATC of 3.3 mg/kg total PCBs was determined based on the EC20 value for the Phase III metamorph malformation endpoint (based on both measured and spatially weighted total PCB concentrations). This MATC was supported by result of an amphibian community study conducted between 1999 and 2000, in which detailed data were collected for wood frogs (e.g., numbers of frogs entering and leaving pools, numbers of metamorphs captured leaving the pools). Species abundance, richness, and malformation rates were assessed for multiple species in selected vernal pools, which species richness, abundance of salamanders, and malformation rates in larval wood frogs all exhibiting concentration-dependence for PCB exposures.

The MATC from this study (3.3 mg/kg total PCBs) is considered to be applicable to the KIH evaluation given the similarity of the Aroclor composition of PCB mixtures, the ecological relevance of test species (particularly leopard frogs), and the sensitivity of the endpoints used in the study. The 95th percentile total PCB concentration from the

PC-W management unit is 1.8 mg/kg dw and other KIH management units with amphibian habitat have 95th percentile PCB concentrations below 0.4 mg/kg dw. Therefore, the concentrations of PCBs in sediments adjacent to Orchard Street Marsh do not appear to reach levels of ecological concern to sensitive amphibian species.

6.3.2 National Environmental Research Park

Hopkins et al. (2000) studied the adverse effect of by coal combustion wastes to larval bullfrogs (*Rana catesbeiana*) at the National Environmental Research Park located near Aiken, South Carolina. The test species is also observed in KIH, and the COPCs included several metals that are elevated in KIH sediment. Larval bullfrogs were collected at four sites (two polluted by and two unpolluted by coal combustion wastes) during the study. The authors documented an increased incidence of axial malformations in bullfrog larvae inhabiting two sites contaminated with coal combustion wastes (e.g., 18 and 37% of larvae exhibited lateral curvatures of the spine, whereas zero and 4% of larvae from two reference sites had similar malformations). In addition, malformed larvae from the most contaminated site had decreased swimming speeds compared with those of normal larvae from the same site.

Larvae from the most heavily polluted site had significantly higher tissue concentrations of potentially toxic trace elements, including arsenic, cadmium, selenium, copper, chromium, and vanadium, compared with conspecifics from the reference sites. The authors concluded that the complex mixture of contaminants produced by coal combustion is responsible for the higher incidence of adverse effects. Some of the constituents that correlated with response magnitude included:

- Arsenic—the sites contaminated with coal combustion wastes contained 29–49 mg/kg dw arsenic, relative to 2 mg/kg at the two reference sites with no known anthropogenic input of contaminants. The 95th percentile arsenic concentration from the PC-W management unit is 10 mg/kg dw, which is below the concentration associated with effects to bullfrogs.
- Copper—the sites contaminated with coal combustion wastes contained 44–85 mg/kg dw copper, relative to 9—19 mg/kg at the two reference sites with no known anthropogenic input of contaminants. The 95th percentile copper concentration from the PC-W management unit is 110 mg/kg dw, which exceeds the concentration associated with effects to bullfrogs.
- Chromium—the sites contaminated with coal combustion wastes contained 22–24 mg/kg dw chromium, relative to 8 mg/kg at the lower of the two reference sites with no known anthropogenic input of contaminants. The 95th percentile chromium concentration from the PC-W management unit is 6,176 mg/kg dw, which is much higher the concentration associated with effects to bullfrogs.

The above study provides some information of relevance to KIH. However, the study is confounded by the elevated selenium (and other) concentrations, particularly as selenium is the most frequently documented teratogen of the trace elements having elevated levels in larval bullfrogs from the two polluted sites (Hopkins et al. 2000).

6.4 Conclusions

The available literature information provides some information of the potential effects of contaminated sediments to herptiles, specifically the sensitivity of amphibians to sediment associated PCBs and metals. This information does not provide compelling evidence for adverse effects associated with any the COPCs for which sediment toxicity information is available. However, there are some indications of potential contaminant-based risks to herptiles given the elevated levels of chromium, and to a lesser extent copper, relative to sediment effects levels observed at other sites. Although the chromium found in the vicinity of Orchard Street Marsh has been demonstrated to have low bioavailability relative to other sites, it is not known whether the predominantly hexavalent speciation or other site-specific factors are sufficient to ameliorate toxicity to herptiles in KIH.

The field studies of herptiles adjacent to the Site, particularly those characterizing the Orchard Street Marsh, provide anecdotal confirmation that populations of herptiles, including species sensitive to contamination (such as the leopard frog *L. pipiens*), can at least partially withstand the contamination. However, the site surveys do not provide a basis for concluding that the population density or developmental health of these organisms is not impaired. This evaluation is highly uncertain given that no site-specific toxicity data are available, available field studies are semi-quantitative, and given that the literature review could not identify reliable amphibian ecotoxicity benchmarks for chromium or PAHs, two of the priority COPCs identified in sediments adjacent to marsh habitats.

From the risk evaluations of other organism groups, specifically wildlife and bottom fish, it is evident that the sediment conditions at the mouth of the unnamed creek (draining Orchard Street Marsh into the PC-W management unit) already pose moderate risk to ecological receptors overall. This area contains elevated concentrations of PAHs, PCBs, and chromium, and the combination of risks from these substances results in a level of ecological risk worthy of management attention. Risks to herptiles, if present, would simply increase the overall level of ecological risk in this area. These contaminant-based risks must be juxtaposed against the fact that the mouth of the unnamed creek currently includes substantial productive wetland habitat, which is essential for many of the wildlife and herptiles observed in the area. Accordingly, proposed management solutions for this area must consider both potential contaminant stressors as well as biophysical stressors associated with physical intervention in sensitive habitats with SAR species. Similar considerations may apply for other portions of KIH shoreline habitat, including near Douglas Fluhrer Park, whereas risks to some receptors have been identified due to PAH contamination.

6.5 Residual Uncertainties

The conclusions described in Section 6.4 have several caveats based on the high level of uncertainty for herptiles relative to other receptor groups:

- Reptile risks unknown—Reptilian Species at Risk (SAR) have been identified in KIH, such as the stinkpot turtle and northern map turtle. The community survey data available for the area south of Belle Park are inadequate to discern whether soil or sediment contamination has damaged individuals or populations of these species.
- Amphibian habitat distribution—To date, research on amphibian communities in KIH has focussed on the Orchard Street Marsh and adjacent aquatic environments. In addition to the Parks Canada property, turtles have been anecdotally observed in other shoreline areas of KIH, including near Douglas Fluhrer Park. In conjunction with remedial planning for KIH, it is recommended that more detailed surveys of amphibian and reptile habitats be conducted along the western shoreline. This information may not be adequate to quantify risks to these species or to identify contaminant benchmarks for their protection. However, at minimum they would provide input into the selection of the shoreline management alternatives where sediments have been identified as posing risk to other receptor groups.
- Other COPCs—For some primary COPCs (e.g., PAHs, mercury), insufficient data are available to evaluate potential risk specific to these contaminant groups.

- Soil versus sediment exposures—Related to the lack of detailed habitat and biological information for resident herptiles is uncertainty regarding the relative contribution of terrestrial (soil) versus aquatic (sediment and water) based uptake pathways. This information gaps makes it difficult to assign risks to the KIH water lots as distinct from upland contamination sources such as the former tannery and smelter operations brownfield area.
- Lack of site-specific toxicity data—no toxicity tests (water or sediment) have been conducted using amphibian species. Amphibian toxicity testing is much less developed in Canada relative to freshwater invertebrate toxicity testing. However, methods are currently under development by Environment Canada in partnership with commercial laboratories, and they are collectively working toward a standardized laboratory protocol for a chronic larval development and metamorphosis using *L. pipiens* (Lo et al. 2014).

7.0 HUMAN HEALTH RISK ASSESSMENT

7.1 Introduction

Health Canada reviewed the RMC-ESG (2014) reporting package and determined that the HHRA (Chapter IV) needed to be refined in recognition of several issues identified by Health Canada. The key issues identified by Health Canada are summarized in Section 7.1.1 below. This risk refinement focuses on the issues identified by Health Canada as requiring refinement, and retains the HHRA components from RMC-ESG (2014) that were acceptable to Health Canada. The risk refinement therefore builds on the RMC-ESG (2014) risk assessment, with refining of risks for select parameters, pathways and assumptions, based on comments provided by Health Canada. This section emphasizes the rationale and details for required changes to the RMC-ESG risk models, and does not duplicate information presented in RMC-ESG (2014) that has remained unchanged.

7.1.1 Key Topics Identified by Health Canada as Requiring Refinement

The following is a summary of the key issues identified by Health Canada as requiring refinement, based on their review of the RMC-ESG (2014) HHRA.

- Selecting and screening of COPCs—Although RMC-ESG (2014) captured the primary substances of concern in the HHRA, Health Canada requested that the COPC screening be revisited to identify whether additional substances should have been retained for evaluation (e.g., volatile organics or additional metals).
- Exposure point concentrations—Several concerns were raised with the choice of exposure metric used in the HHRA, based on the upper confidence limit of a mean of data from the entire harbour, rather than considering that individual receptors may access the shoreline at various locations along the western shore of KIH which may have localized higher concentrations of COPCs.
- Sediment ingestion during in-water recreational activities—Comments were made regarding the assumptions related to the incidental ingestion of sediments in surface water during recreation.
- Fish ingestion assumptions—Several comments were made by Health Canada on the fish ingestion pathway, particularly with respect to amortization of fish ingestion rates.
- Sediment dermal adherence—Several comments related to the potential over-conservatism in dermal adherence factors (e.g., the use of soil dermal adherence factors to evaluate exposure to suspended sediments, uncertainty associated with the use of the Shoaf et al. (2005a,b) dermal adherence factors to estimate dermal exposure to bedded sediments submerged under water), particularly given the importance of this pathway for driving overall risk in the RMC-ESG HHRA).
- Toxicity reference values—Refinement of the lead TRV assessment was recommended.

7.1.2 Overview of Methods

The RMC-ESG (2014) HHRA was refined to address the concerns raised by Health Canada in Section 7.1.1, above. The risk refinement includes an evaluation of current conditions. No evaluation of potential future scenarios has been conducted as part of the risk refinement. Although brownfield redevelopment scenarios have been tabled for the Orchard Street Marsh and associated riparian areas, there is currently insufficient information on future site use to prescribe any specific future exposure scenarios.

The human health risk refinement is supported by the following sections:

- Section 7.2—Refined COPC Screening;
- Section 7.3—Updated Exposure Scenarios and Exposure Pathways;
- Section 7.4—Toxicity Assessment; and
- Section 7.5—Risk Characterization and Evaluation of Uncertainty.

The human health risk refinement was completed using the following Health Canada guidance documents:

- Health Canada 2010a. *Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment*, Version 2.0, 2010, Revised 2012;
- Health Canada 2010b. *Federal Contaminated Site Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values and Chemical-Specific Factors*, Version 2.0, 2010;
- Health Canada 2010c. *Federal Contaminated Site Risk Assessment in Canada, Part V: Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals (DQRA$_{Chem}$)*, September 2010; and
- Health Canada 2013. *Interim Guidance on Human Health Risk Assessment for Short-Term Exposure to Carcinogens at Contaminated Sites*.

7.1.3 Human Use of Kingston Inner Harbour and Exposure Pathways and Areas Considered

Human Use of Kingston Inner Harbour

The human health risk refinement considered potential exposure of people to three areas of Western KIH, referred to as "exposure areas" – North, Central and South (see **Figures 17, 18 and 19**). The three areas of KIH were selected based on consideration of natural characteristics of the shoreline, existing access, and desirability for recreational use. The identification of separate exposure areas is a direct response to Health Canada's concern that different areas of the KIH shoreline may have different human exposure profiles. A description of each area is provided below.

North Exposure Area

The north exposure area is adjacent to the former Belle Landfill, Belle Island and the Orchard Street Marsh. The shoreline along the former Belle Landfill and Belle Island is in close proximity to walking trails. This area has sediments that are exposed when the water levels are low, and the sediments consist of a firm muddy substrate near Belle Island (**Figure 17** – Photographs 1-3), and loosely consolidated mud in the vicinity of Orchard Street Marsh. The majority of the exposed sediments in this area do not support human weight for hiking and would inhibit access to the water (**Figure 17** – Photograph 4). The shallow water and dense macrophyte beds in this area would also make the water area undesirable for swimming.

Central Exposure Area

The central exposure area is adjacent to Kingston Rowing Club, Emma Martin Park, and the former Woolen Mill. A limited area near the shoreline has sediments that are occasionally exposed when water level changes; however, the majority of the sediments here are submerged under water (hereafter referred to as 'submerged bedded sediments'). Access to the water in this area is restricted somewhat by sheet pile, stone or riprap retaining walls

(**Figure 18** – Photograph 3). The water of KIH is most accessible to the public by a concrete boat launch ramp at Emma Martin Park, or from the floating dock or boat launch ramp provided at the Kingston Rowing Club (**Figure 18** – Photograph 4). Presence of macrophyte beds in this area would make the water area undesirable for swimming.

South Exposure Area

The south exposure area is adjacent to Douglas Fluhrer Park and Anglin Bay; this area hosts an active marina and shipyard. Douglas Fluhrer Park provides walking trails along the shoreline of KIH; however, access to the water is somewhat limited due to steep and vegetated rip-rap banks. There are no exposed sediments in the south exposure area; the sediments here are submerged under water. Water in this area contains dense macrophyte beds and presence of woody debris (e.g., derelict wooden structures) that would make this area undesirable for swimming (**Figure 19** – Photographs 1-5) but could attract curious pedestrians. Water access in the vicinity of Anglin Bay is limited to a concrete boat launch ramp or floating docks in the marina.

Exposure Pathways Considered

Consultation with Health Canada during the risk refinement indicated a priority for identification of “beach-like” areas along the shoreline. Here, we define beach-like to mean a gently sloping bank of soil/sediment adjacent to the water, and with a substrate type that is highly conducive to human recreation (e.g., wading, digging, picnicking). Under current conditions, there are no sandy beach-like areas in Western KIH, nor are there areas that are enticing to recreational users, as described above. Therefore, human exposure in this area was assumed to occur through limited shoreline use, or via swimming or recreational activities such as boating, where people may occasionally come into contact with submerged, bedded sediments. Accordingly, human contact with bedded sediments was included as an operable pathway for human exposure, but was appropriately limited in magnitude (duration, frequency, and type of exposure) concordant with realistic site use patterns under current conditions. Areas of exposed sediment are present in the north and central exposure areas of KIH during low water levels; however, these areas are not considered “beach-like”. Therefore, it was considered unlikely that people would spend time in areas of occasionally exposed to sediment. If site redevelopment were to result in significant changes to the riparian areas, through re-grading of foreshore, configuration of walkways or access points, or other shoreline alterations, these assumptions would need to be revisited.

It was assumed that dermal contact with bedded sediments would only occur with the top 0 – 15 cm of the sediment profile. This is considered reasonable, as exposure to exposed sediment during periods of low water was assumed to only occur while accessing the shoreline (e.g., it was not assumed that people would be extensively digging in the exposed sediment). A sediment investigation completed by Golder (2013d) showed that deeper sediments may contain higher concentrations of some COPCs than surficial sediments in certain areas of the KIH. In the event of significant sediment disturbance or removal (e.g., during dredging), there is potential for the deeper, more contaminated sediments to become exposed. However, the contamination at depth is not evenly distributed. Additional sampling and/or coring would be required to adequately evaluate the sediment exposure at depths greater than 15 cm. Evaluation of this pathway is considered to be beyond the scope of the human health risk refinement. Furthermore, the risk refinement evaluated a current Site use scenario. If sediment conditions will change in the future, the risk assessment should be updated accordingly.

Summary of Exposure Areas and Management Units Considered in the Risk Refinement

Figures 17, 18, and 19 illustrate the North, Central and South exposure areas and the data considered for each area. The managements units included in each exposure area are shown in **Table 7** below.

Table 7: Areas and Management Units Considered in the Risk Refinement

Receptor	Area	Area Description	Management Units Considered for Each Medium and Area		
			Sediment	Surface Water [2,3]	Fish
Recreational User	Western KIH Exposure Area - North	South of and Adjacent to Former Belle Landfill/ Orchard Street Marsh/ Former Lead Smelter	PC-E, PC-W, TC-OM	PC-W, PC-E, TC-OM, TC-RC, TC-1	Western half of KIH [1]
Recreational User	Western KIH Exposure Area - Central	Former Lead Smelter/ Emma Martin Park/ Woolen Mill	TC-RC, WM	TC-RC, WM, TC-OM, TC-1, TC-2A*, TC-2B*	Western half of KIH [1]
Recreational User	Western KIH Exposure Area - South	Douglas Fluhrer Park/ Anglin Bay	TC-2A, TC-3A, TC-4, TC-AB	TC-2A*, TC-3A*, TC-4*, TC-AB*, WM, TC-2B*, TC-3B*, TC-5*	Western half of KIH [1]

Notes:

KIH = Kingston Inner Harbour; NA = not applicable.

1 – 'Western half of Kingston Inner Harbour' (KIH) includes management units PC-E, PC-W, TC-OM, TC-RC, TC-1, WM, TC-2A, TC-2B, TC-3A, TC-3B, TC-4, TC-5 and TC-AB.

2 – The management units considered for the water pathways for each exposure area evaluated include those identified for sediment exposure and adjacent management units. In some cases, water quality data were not available in a management unit. This is indicated with an asterisk.

3 – In the absence of water quality data for several management units in the South Exposure Area of Western KIH, water quality data from south-central KIH (immediately adjacent to management units TC-3B and TC-5) were included in the data set.

* = water quality data were not available within this management unit

Potential exposure pathways considered in the risk refinement were those related to the aquatic environment (i.e., sediment [incidental ingestion and dermal contact], surface water [incidental ingestion and dermal contact] and fish ingestion). Please refer to RMC-ESG (2014) Chapter IV, Table IV-11 for the rationale for excluding pathways related to soil (e.g., dust inhalation), groundwater, and vapours.

7.2 Refined Contaminant of Potential Concern Screening

A refined screening approach was used to determine the COPCs for human health. A tiered approach was used to identify COPCs, as described below. This approach was applied to the relevant media (sediment, surface water, fish tissue). Further details are provided in the media-specific screening sections below.

1) Step 1—Elimination of substances that are inert or have very low toxicological hazard, where applicable (see Section 7.2.1 [Sediment]);

2) Step 2—Comparison of measured concentrations to health-based guidelines and standards and background sediment concentrations (see Section 7.2.1 [Sediment], Section 7.2.2 [Surface Water] and Section 7.2.3 [Fish]); and

3) Step 3—Comparison of measured concentrations to reference area concentrations, where applicable (see Section 7.2.1 [Sediment]). The 95% UCLM was used to represent KIH sediment concentrations and the 95th percentile concentration was used to represent reference conditions.

In general, Canadian (i.e., CCME and Health Canada) and Ontario (i.e., OMOE) environmental quality guidelines and standards were used in Step 2 of the screening process. In the absence of Canadian environmental quality guidelines and standards for a particular substance, environmental quality criteria from other international regulatory jurisdictions (i.e., the US EPA) were used.

7.2.1 Sediment

7.2.1.1 Addressing Low Hazard Constituents

Some metals and essential minerals are commonly analyzed in environmental samples (as part of the standard suite of metals treated by the analytical method) but generally have low toxicological hazard at environmental concentrations, even at industrial sites. Many of these constituents are present naturally in sediment and are present in a toxicologically inert form, and some are essential micro- and macro-nutrients.

Although essential minerals (i.e., calcium, magnesium, phosphorus, potassium and sodium) may be present in media in the study area, they were excluded from further consideration in the COPC screening process based on their low hazard potential in combination with a lack of relevant screening values. These essential minerals serve a variety of biochemical, intracellular, and ion balance purposes in human tissues, and are naturally occurring substances included in routine analytical chemical analyses. Government agencies often do not develop regulatory criteria for these parameters and other innocuous substances because these constituents:

i) are essential nutrients;

ii) have low hazard potential; and

iii) are not known or expected to be associated with on-site activities (Health Canada 2010c).

7.2.1.2 Comparison to Health Based Criteria and Background/Reference

The maximum measured surficial (0 – 15 cm) sediment concentrations in each exposure area were calculated from the data collected by Benoit and Dove (2006), Benoit and Burniston (2010), Golder (2011, 2012, 2013), RMC-

ESG (2011, 2014[3]) and Tinney (2006) and then compared to health-based guidelines/standards and reference area concentrations as described below.

Health-based criteria were identified to provide a basis for contaminant screening. Currently, there are no human health-based sediment criteria published from a Canadian jurisdiction. In the absence of sediment criteria for human health, soil quality guidelines and standards for residential/parkland use for a direct contact scenario (incidental ingestion and dermal contact) were used in the screening process. It is acknowledged that soil criteria are developed based on exposure factors specific to human interactions with soil, and that human exposure to sediments is typically different from human exposure to soil (e.g., potentially greater dermal adherence and ingestion rates); however, based on the exposure scenario and site conditions at KIH, the soil quality guidelines are considered sufficiently protective of human health. For example, people are not expected to visit the site regularly or participate in high contact-type activities. There are no beach-like areas in KIH, and sediments that would be accessed by receptors are submerged under water.

For screening of human health significance, health-based soil criteria were selected over generic values, with CCME values given preference over OMOE values. Ontario background sediment standards were also considered in the COPC screening process. Where Ontario background sediment standards were higher than health-based criteria, the background standards were selected to screen the data (i.e., if concentrations were below Ontario background sediment standards, the parameter was not considered a COPC). In the absence of Canadian criteria and Ontario background standards, concentrations were compared to health-based US EPA regional screening levels (RSLs) for soil.

The following is a summary of the guidelines and standards considered in the screening process:

1) CCME (1999)—Canadian soil quality guidelines for protection of human health (residential land use). Where available, screening values for relevant pathways were used (i.e., soil ingestion, direct contact). The Canadian soil quality guidelines are typically based on an allocation of 20% of the provisional tolerable daily intake of soil (i.e., assuming 20% of a person's tolerable daily intake of a chemical comes from soil, and the remaining 80% comes from other sources such as food and water);

4) OMOE (2011)—Ontario soil standards (S1 Risk standards) for protection of human health (residential land use). The S1 Risk standards are derived assuming a high-frequency, high-intensity, human health exposure scenario equivalent to that of a surface soil contact scenario at a residential/parkland/institutional or agricultural/other site, and assume that sensitive receptors (e.g., toddlers, pregnant women) are present 24 hours per day, 7 days per week. The S1 Risk value is calculated using toxicity reference values (TRVs) and a soil ingestion and dermal exposure model.

5) OMOE (2011)—Ontario background sediment standards, which are considered to provide human health and ecosystem protection consistent with background and protective of sensitive ecosystems.

6) In the absence of health-based Canadian criteria (CCME or OMOE) and Ontario background sediment standards, the US EPA RSLs for Residential Soil (direct contact pathways) for Chemical Contaminants at Superfund Sites (US EPA 2015) were used to screen for COPCs. For non-carcinogens, the RSLs were

[3] The RMC-ESG 2014 sediment data included data collected by Benoit and Dove (2003), Golder (2010) and Malroz (2005).

adjusted to an HQ of 0.2 (to reflect an allocation of 20% of a person's tolerable daily intake from soil), and for carcinogens, the RSLs were adjusted to reflect a cancer risk level of 1 in 100,000.

The sediment screening is presented in **Appendix C – Table 1**. **Table 8** below presents a summary of the sediment COPCs for each exposure area. The RMC-ESG (2014) identified copper, zinc, DDT, chlordane, fluoranthene, phenanthrene, naphthalene and pyrene as COPCs; however, based on the refined screening approach, including comparison to health-based soil guidelines, and an updated data set (considering only surficial sediments and removal of dredged samples from the data set), these chemicals were no longer considered COPCs for human health.

Based on the refined screening, aluminum, cobalt, manganese and vanadium were identified as additional COPCs and were carried forward in the risk refinement.

Table 8: Summary of Sediment COPCs Retained for the Human Health Risk Refinement

COPC	Exposure Area of Western KIH		
	North	Central	South
Metals			
Aluminum	√	√	√
Antimony	√	√	√
Arsenic	√	√	√
Chromium (III) [1]	√	√	√
Cobalt	X	√	X
Lead	√	√	√
Manganese	√	√	√
Mercury (inorganic)	X	√	X
Vanadium	√	√	√
Organics			
Total PCBs [2]	√	√	√
Carcinogenic PAHs [3]	√	√	√

Notes:
√ = COPC; X = not a COPC
1 – Chromium is present in surficial sediment in the Inner Harbour in its Cr(III) form (RMC-ESG 2014).
2 – Data were available for non-coplanar PCBs. Dioxin-like PCB congener data are not available (they have not been analyzed for in sediment; RMC-ESG [2014]).
3 – Carcinogenic PAHs include benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene.

Although sediment iron concentrations exceeded the US EPA RSL for soil, iron was not retained as a COPC for human health for the following reasons:

- Concentrations in the three exposure areas were similar to reference area concentrations, and generally close to background levels within KIH. A discussion of the distribution of iron in KIH sediment is provided in Section 2.5.3.
- Iron is considered an essential nutrient.
- There are no suitable toxicity reference values for assessing chronic exposure to iron (values have not been derived by Health Canada, the US EPA Integrated Risk Information System [IRIS], the Agency for Toxic

Substances and Disease Registry [ATSDR], the Netherlands National Institute of Public Health and the Environment [RIVM] or the World Health Organization [WHO]).

In Health Canada's 2014 expert support comments on the RMC-ESG (2014) deliverable (**Appendix D**), Health Canada noted that data for volatile organics in sediment were reported for one sample from KIH in a previous version of RMC-ESG Chapter II (RMC-ESG 2009), including relatively low but measureable concentrations of benzene, toluene ethylbenzene, and xylenes, isopropylbenzene and trimethylbenzene. Golder reviewed the data from this sample (sample ID 08-42135, as referenced in RMC-ESG [2009]). The sample was collected in an unnamed creek in management PC-W, at a depth of 25 to 30 cm, which is outside of the expected zone of direct contact for human health. Regardless, the detectable concentrations identified are below health-based soil guidelines/standards.

7.2.2 Surface Water

Surface water chemistry data were available for KIH (RMC-ESG 2014), and included data for a subset of metals (total and dissolved antimony, arsenic, chromium, copper, lead and zinc), PAHs, and PCBs (Aroclors 1254 and 1260, and total PCBs). For high molecular weight organics that are not soluble in water (e.g., PAHs and PCBs), a quantitative evaluation of dermal exposure via surface water was considered to be inappropriate. The state of practice in human health risk assessment does not currently support a sufficiently reliable exposure estimate for trace concentrations of hydrophobic constituents in surface water. The detected concentrations of these parameters would be related to suspended particulates.

Maximum measured total surface water concentrations in Western KIH were compared to applicable screening guidelines. For this purpose, health-based criteria were selected for screening rather than aesthetic objectives whenever available. In the absence of health-based Health Canada drinking water quality guidelines and OMOE drinking water standards, the US EPA RSLs for Residential Tapwater (US EPA 2015) were used if available. The US EPA RSLs were adjusted to reflect the acceptable target risk levels in Canada (i.e., RSL × 0.2 for non-carcinogens and RSL × 10 for carcinogens). The potable water guidelines are derived based on the average daily intake of drinking water for an adult (Health Canada 1995), and recreational users would be exposed to a much lower volume of incidentally ingested surface water during recreational activities. Therefore, the potable water guidelines were adjusted by a factor of 10 to reflect an incidental ingestion rate that is 10 times lower than the intake of potable drinking water, as per guidance from the World Health Organization (WHO 2003). The WHO (2003) adjustment of 10% of potable water intake is based on a swimming scenario, and is therefore reasonable for the recreational user, who was assumed to occasionally recreate in KIH. Results of the surface water screening are summarized in **Appendix C – Table 2**.

The following COPCs were identified in surface water:

- chromium; and
- lead.

Chromium and lead were also identified as COPCs in sediment.

7.2.3 Fish

Soil criteria do not account for the potential for chemicals to biomagnify in the aquatic food web, and are therefore not suitable for identifying biomagnifying substances that should be considered in evaluating risks associated with the consumption of fish from the site. Methylmercury and PCBs, which are both site-related, were identified as biomagnifying chemicals, and were retained as COPCs to be evaluated for the fish consumption pathway. Certain pesticides (e.g., DDT) are site-related and also potentially biomagnify; however, pesticides were not detected in surficial sediments and were not measured in fish tissues. PAHs were identified as COPCs in sediment; however, PAHs undergo metabolic transformation in fish (Johnson et al. 2002) and are therefore not considered to be biomagnifying COPCs. Fish tissue data for PAHs were not available (they were not measured in fish; RMC-ESG 2014).

Arsenic can accumulate in fish tissues but is primarily in the form or organoarsenic compounds which are relatively non-toxic to humans (Neff 1997). Arsenic speciation analysis conducted in fish tissues from KIH indicated non-detectable concentrations of organic arsenic. Therefore, arsenic was not considered to be a COPC in fish tissue.

Fish fillet chemistry data were available for the following species considered in the assessment: largemouth bass, northern pike, and perch (fish species selected based on survey data; see Section 7.3.1.3 for details). Tissue chemistry data were available from RMC-ESG (2014) and Golder (2011), and included metals and metalloids (arsenic, chromium [as hexavalent Cr], copper, lead, methylmercury, nickel and zinc) and PCBs. In addition to identifying potentially biomagnifying chemicals, maximum measured concentrations in fillet samples of the species of interest were screened against the US EPA Region 3 RSLs for fish ingestion (US EPA 2015). Both non-carcinogenic and carcinogenic screening levels are available. Non-carcinogenic RSLs were adjusted to an HQ of 0.2, and carcinogenic RSLs were adjusted to reflect a cancer risk level of 1 in 100,000. The fish tissue screening is provided in **Appendix C – Table 3**.

The following COPCs were identified in fish:

- lead;
- mercury (as methylmercury); and
- PCBs.

Lead, mercury (inorganic mercury) and PCBs were also identified as COPCs in sediment.

7.2.4 Summary of Contaminants of Potential Concern Identified in the Human Health Risk Refinement

The results of the COPC screening for the human health risk refinement are summarized in **Table 9** below. Based on the screening process outlined above, several metals, carcinogenic PAHs and total PCBs were identified as COPCs in one or more exposure zones in sediment. Chromium and lead were also identified as COPCs in surface water, and lead, mercury (as methylmercury) and PCBs were identified as COPCs in fish. Although the same COPCs were not identified in each media, where possible, they were evaluated in all relevant exposure pathways as part of the human health risk refinement. For example, exposure to arsenic, hexavalent chromium, lead, methylmercury and total PCBs were evaluated for the fish ingestion pathway even though only lead, methylmercury and total PCBs were identified as COPCs in fish tissue. This multimedia approach was conducted to account for COPC exposure through multiple routes and pathways. In some cases, this was not possible because surface water and fish tissue chemistry data were not available for all of the COPCs identified in sediment, as indicated in **Table 9**.

Table 9: Summary of Contaminants of Potential Concern Identified in the Human Health Risk Refinement

COPC	Sediment	Surface Water	Fish
Metals			
Aluminum	√	No data	No data
Antimony	√	X	No data
Arsenic	√	X	X
Chromium	√ (Cr [III])[1]	√	X
Cobalt	√ [4]	No data	No data
Lead	√	√	√
Manganese	√	No data	No data
Mercury (inorganic in sediment; methylmercury in fish)	√ [4]	No data	√
Vanadium	√	No data	No data
Organics			
Total PCBs [2]	√	X	√
Carcinogenic PAHs [3]	√	X	No data

Notes:

√ = COPC; X = not a COPC

1 – Chromium is present in surficial sediment in the Inner Harbour in its trivalent form (RMC-ESG 2014).

2 – Data were available for non-coplanar PCBs. Congener data for dioxin-like PCBs were not available as PCB congeners were not analyzed (Section 2.5.4).

3 – Carcinogenic PAHs include benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene.

4 – Cobalt and mercury were identified as COPCs in sediment only in the Central exposure area of Western KIH.

7.3 Updated Exposure Assessment

This section describes the human receptors, exposure scenarios and operable exposure pathways evaluated in the risk refinement. Tables are provided summarizing receptor characteristics (updated where necessary based on feedback from expert support, such as for incidental water ingestion rates), exposure assumptions (updated where necessary based on feedback from expert support, such as for frequency of exposure), and updated exposure concentrations (taking into account the updated data sets and the management units described in Section 2.6).

7.3.1 Scenarios and Exposure Pathways

Three areas of Western KIH were evaluated in the risk refinement—North, Central and South—as defined in Section 7.1.

Potential exposure pathways considered in the risk refinement are those identified by Health Canada as requiring refinement, and are those related to the aquatic environment (i.e., sediment, surface water and fish). The following exposure pathways were re-evaluated in the risk refinement:

- Incidental ingestion of suspended sediment (in shallow waters);
- Dermal contact with bedded sediments;
- Incidental ingestion of surface water (in deeper waters; as total COPC water concentrations);

- Dermal contact with surface water; and
- Ingestion of Fish.

For each exposure area (North, Central or South), two scenarios were considered as follows:

1) Shallow Water/Shoreline Scenario

- Activities—The shallow water/shoreline scenario considered the following activities: wading or playing in the waters adjacent to the shoreline, and consumption of fish from the Western KIH.
- Exposure Pathways—The shallow water/shoreline scenario considered the following exposure pathways: dermal contact with bedded sediments and surface water, incidental ingestion of suspended sediments, and ingestion of fish.

2) Deep Water Scenario

- Activities—The deep water scenario considered the following activities: boating activities and swimming in deeper waters (e.g., jumping off the boat for a swim), and consumption of fish from Western KIH.
- Exposure Pathways—The deep water scenario considered dermal contact with surface water, incidental ingestion of total COPC concentrations in surface water (rather than ingestion of suspended sediments), and ingestion of fish. Dermal contact with bedded sediments was not retained for the deep water scenario, as it was assumed that someone would not be in contact with deep bedded submerged sediments while swimming, and would likely access deeper waters via a vessel (e.g., a boat), rather than via the shoreline.

It was assumed that people would be in direct contact (experiencing dermal contact and incidental ingestion) with water and sediment during summer months (i.e., a period of 17 weeks, from June through September).

Ingestion of fish from the harbour was assumed to be year round (not seasonal).

For the sediment and water pathways, frequency of exposure was assumed to vary for North and Central versus South exposure areas, based on natural characteristics of the shoreline, existing access, and desirability for recreational use. As described in Section 7.1.3, the aesthetic value of the shoreline area varies with the South exposure area offering more desirable recreational use than the North and Central exposure areas (see also **Figures 17, 18 and 19**). The risk refinement therefore considered this aspect of the Site in the assumptions of exposure frequency. The following exposure frequency was assumed for the three exposure areas considered:

- one event per week for the North and Central areas; and
- two events per week for the South area.

The following sections outline the issues related to exposure identified by Health Canada in their review of the RMC-ESG (2014) HHRA, and the refinements made.

7.3.1.1 Sediment Pathway Refinements

Table 10: Sediment Pathways—Summary of Issues and Refinements, with Assumptions and Rationales

Issue Summary	Refinements Made
Incidental Ingestion of Suspended Sediment while Swimming	
The exposure scenario evaluated by RMC-ESG (2014) for KIH involved a receptor wading and swimming in the near-shore water, where they may be exposed to COPCs in sediments submerged under water, including suspended sediments and bedded sediments. For exposure to bedded sediments, RMC-ESG (2014) assumed sediment ingestion rates of 200 mg/day for toddlers and 100 mg/day for adults, for people in contact with exposed sediments (i.e., not submerged under water). Health Canada indicated that these rates would not be relevant for the site, given that people are not expected to be in contact with exposed sediments, and incidental ingestion of sediment would likely occur primarily via incidental ingestion of suspended sediment in surface water while playing in the water. For exposure to suspended sediments, RMC-ESG used a suspended sediment ingestion rate of 1.5 mg/day. However, Health Canada recommended that values proposed by Wilson and Meridian, for incidental ingestion of suspended sediments during in-water recreational activities, be considered, rather than the lower suspended sediment rates (1.5 mg/day) used in the HHRA.	People were assumed to occasionally swim or recreate in Kingston Inner Harbour, and could incidentally ingest suspended sediment while swimming/recreating in shallow waters close to the shoreline. The risk refinement used the suspended sediment ingestion rate recommended by Health Canada (i.e., the Wilson et al. [2015] rate of 7.7 mg/day) to evaluate incidental ingestion of suspended sediments while recreating in shallow waters.
For several COPCs, RMC-ESG (2014) used 95% UCLM concentrations for the entire KIH (i.e., the full area defined as the APEC) to represent exposure concentrations. Health Canada did not agree with this approach, so we identified areas that reflect exposures for a plausible weighted average scenario (see Section 3.1 and 7.3.2.1).	The risk refinement considered surface sediments (0 to 0.15 m), and estimated exposure for three areas of Western KIH, rather than using a 95% UCLM for the entire inner harbour, so as to not underestimate potential risks for receptors who may visit areas with localized higher concentrations of COPCs in sediments.

Dermal Contact with Submerged Bedded Sediments	
RMC-ESG (2014) evaluated risks associated with dermal contact of hands, arms and legs with sediment, and applied dermal adherence factors for sediments reported by Shoaf et al. (2005a,b) to evaluate exposure to bedded sediments submerged under water. RMC-ESG applied soil dermal adherence factors from Health Canada PQRA Part I (2010a) to evaluate exposure to suspended sediments. Health Canada indicated that there is significant uncertainty associated with the use of the Shoaf et al. (2005a,b) dermal adherence factors to estimate dermal exposure to bedded sediments submerged under water, and suggested that refinement of dermal exposure estimates be considered. Health Canada indicated that if dermal exposure were to be re-evaluated, one potential approach would be to use one set of dermal adherence factors to estimate combined adherence of both bedded sediments submerged under water and suspended sediments in water, rather than considering them separately and adding the exposures, because exposure to bedded and suspended sediments in water would generally occur simultaneously for receptors playing in shallow water along the shoreline. Furthermore the existing dermal adherence factors likely overestimate adherence for both bedded and suspended sediments in water.	There is uncertainty in the evaluation of contaminant exposure from dermal contact with sediments. The risk refinement considers dermal contact of sediment with feet, based on the following rationale: 1 –- The exposure to sediments at the site is expected to be only with submerged bedded sediments (sediments under water), as there are no beach-like areas. Sediment contact is expected to be low or incidental only, as the recreational activities that people are expected to be participating in (e.g., swimming, windsurfing, boating, and fishing) are not typically expected to result in frequent or significant sediment contact. 2 –- The water in areas where people may be recreating (e.g., in the lower half of the western shoreline of the inner harbor) is accessed by climbing down riprap or by jumping off of docks into the water. Much of the sediment is expected to wash off as people move through or exit the water. It is therefore considered reasonable to assume that feet would be the only part of the body in direct contact with the submerged bedded sediments. The risk refinement used different dermal loading estimates, with assumptions and rationale as described below. 3 –- We understand the importance of comparing the expected exposure condition with that of the experimental study used to derive absorption estimates. The conditions/exposure scenario at the site do not fall clearly into any of the categories for which dermal sediment adherence factors are available. 4 –- The sediments in KIH are comprised of primarily silt and clay with relatively high organic carbon content (greater than 10% in some locations). People are not expected to come into contact with exposed sediments, based on the current site conditions (there are no beach-like areas with exposed sediments). 5 –- The Kissel 1996 dermal adherence factor of 6.7 mg/cm^2 for feet, for children exposed to lake shoreline mud, during unscripted play with shoes off (2nd exposure) was used in the risk refinement. This rationale for using this dermal adherence factor is based on the following: a) The available data (from Shoaf et al. 2005a,b and Kissel 1996) are for “shoes on” versus “shoes off”. We considered the “shoes off” data, as it was considered to be likely that some people would be barefoot in the water. b) We also considered sediment type. Although the Kissel 1996 data do not indicate particle size, the description of “lake shoreline mud” appears to be more consistent with the fine particle sized sediment and higher organic carbon in sediment at the site (compared to coarse data available from the Shoaf et al. 2005b study). The site surficial submerged bedded sediments primarily consist of silt and clay with an organic carbon content >2% (and >10% in about 20% of samples).

c) Because our exposure scenario considers submerged bedded sediments, and because sediment is expected to wash off as people move through or exit the water, the lower of the two Kissel 1996 values may be more reasonable, and is still expected to be protective of both direct sediment contact and contact with suspended sediments, as the dermal factors are conservative. The difference between the two scenarios considered by Kissel 1996 appears to be exposure time, with the first exposure being for 10 minutes, and the second for 20 minutes.

6 –- We reviewed the Shoaf et al. (2005a) article on adult dermal sediment loads, and the conditions/exposure scenarios in the study are not consistent with those at our site. For example:

a) only one participant in the study was barefoot, while this would be very unlikely at our site because of the 'mud-like' sediment conditions in the areas that people may be in contact with sediments (they would lose their shoes in the sediment)

b) the sediments in the study were described as very fine to fine sand, with a mean organic carbon content of 0.58%, while the sediments in the areas where people may be exposed in KIH are comprised of primarily silt and clay with a relatively high organic carbon content (greater than 10% in some locations).

7 –- For teens and adults, in consideration of expected exposure condition versus the experimental study used to derive absorption estimates, and in the absence of sediment dermal adherence factors for adults for a similar exposure condition, the Kissel 1996 dermal adherence factor of 6.7 mg/cm^2 for children's feet was used. Although this value is for children, it is more consistent with the expected exposure conditions at the site (shoes off, "mud-like" sediments), and is more conservative than the Shoaf et al. (2005a) value of 0.58 mg/cm^2 for adults.

8 –- It was assumed that people would be in contact with sediment for one hour per event, and that sediment could adhere for two hours. An amortization term of two hours/24 hours was incorporated into the dose estimation for dermal exposure. Dermal exposure to soil/sediment is typically assumed to occur as an event, with the soil/sediment assumed to stay adhered to the skin until the next event (or until it is washed off). In the exposure scenario for this Site, where exposure to sediments is with submerged, bedded sediments, it is expected that the sediment would wash off of feet as people move through or swim in the water, and exit the water (there are no beach-like areas, so access is generally via rip rap or off of docks).

It is also assumed that people would wash or clean their feet following recreational use. It was therefore considered reasonable to apply this term of 2 hours/24 hours.

	9 –- In the absence of sediment dermal absorption factors, the soil dermal absorption factors (i.e., from Health Canada PQRA Guidance - Part II) were applied in the dose estimation calculations for the sediment dermal contact pathway.
For several COPCs, RMC-ESG (2014) used 95% UCLM concentrations for the entire KIH (i.e., a single APEC) to represent exposure concentrations. Health Canada did not agree with this approach, so we identified areas that reflect exposures for a plausible weighted average scenario.	The risk refinement considered surface sediments only, and estimated exposure for three areas of Western KIH, rather than using a 95% UCLM for the entire inner harbour, so as to not underestimate potential risks for receptors who may visit areas with localized higher concentrations of COPCs in sediments.

7.3.1.2 Surface Water Pathway Refinements

Table 11: Surface Water Pathways—Summary of Issues and Refinements, with Assumptions and Rationales

Issue Summary	Refinements Made
Incidental Ingestion of Surface Water while Swimming	
RMC-ESG (2014) did not consider incidental ingestion of COPCs in surface water as a pathway. Health Canada indicated that it would be useful to evaluate risks associated with consumption of surface water during recreation based on total COPC concentrations in surface water as a check for comparison with the estimates based on predicted exposure to suspended sediments.	People were assumed to occasionally swim or recreate in Kingston Inner Harbour, and could incidentally ingest surface water while swimming/recreating. Therefore, incidental ingestion of surface water was included as a pathway. For shallow waters close to the shoreline, incidental ingestion of suspended sediments in water was included as a pathway (see Section 7.3.1.1). For deeper waters, incidental ingestion of water was based on total COPC concentrations and an incidental surface water ingestion rate appropriate for swimming. The risk refinement used an incidental surface water intake of 50 mL/hour from Dufour et al. (2006) as cited in Wilson et al. (2015) for all age groups evaluated.
Dermal Contact with Surface Water while Swimming (Whole Body)	
RMC-ESG (2014) did not consider dermal contact with COPCs in surface water as a pathway.	Dermal exposure to surface water was included as a pathway for the risk refinement. It was assumed that people may be in contact with surface water while swimming or conducting recreational activities (whole body contact). For high molecular weight organics that are not soluble in water (e.g., PAHs and PCBs), a quantitative evaluation of dermal exposure via surface water was considered to be inappropriate. The state of practice in human health risk assessment does not currently support a sufficiently reliable exposure estimate. The detected concentrations of these parameters would be related to suspended particulates.

7.3.1.3 Fish Ingestion Pathway Refinements

Table 12: Fish Ingestion Pathway—Summary of Issues and Refinements, with Assumptions and Rationales

Issue Summary	Refinements Made
Fish Species Included in the Risk Assessment	
In the RMC-ESG (2014) risk assessment, fish data were not separated by species. Health Canada suggested exploring the potential for risks associated with selective consumption of a species with the highest concentrations, in case some people may have a preference for a particular species.	Available fish data (i.e., fillet samples from perch, largemouth bass and pike), from Western KIH were pooled, based on the following rationale: a) A 2003 survey conducted by the OMOE ("Results of the 2003 Guide to Eating Ontario Sport Fish Questionnaire") indicated that there was no particular preference for fish species. b) Survey data show the most frequently consumed sport fish in Ontario were walleye (67.2%), smallmouth bass (56.4%), yellow perch (46.8%), largemouth bass (43.2%) and northern pike (39.2%). Of these species, fillet data were available for perch, largemouth bass and pike. c) The home range of perch, largemouth bass and pike, is expected to be within the spatial extent of KIH (Golder 2012a) d) People may fish anywhere in KIH e) Survey data indicate that most people consume the fillet of fish (most frequently eaten parts included skinless dorsal fillet [47.4%] and skin-off full-side fillet [31.9%]).
Fish Consumption Rates and Amortization	
The RMC-ESG (2014) risk assessment used fish consumption rates developed based on information from the OMOE (2006) document 2003 Guide to Eating Ontario Sport Fish Questionnaire which is relevant for fish consumption in the Great Lakes. The meal size of 236 g/meal and the consumption frequency of 39 meals/year were used to derive an average daily consumption rate of 24.9 g/day. Health Canada indicated that this results in a significant amortization of exposure to COPCs in fish tissue. Health Canada also indicated that it was not clear whether survey respondents consumed the 39 meals throughout the year (e.g., some fish frozen for future consumption) or whether consumption occurred primarily within a limited fishing season. Health Canada recommended that exposure amortization be completed on a chemical and site-specific basis with supporting scientific rationale.	Fish consumption rates were assumed to be similar across all three exposure areas evaluated as part of the risk refinement. It was assumed that people may be consuming fish throughout the year (e.g., people may store fish for future consumption). The following modifications/assumptions regarding the fish ingestion pathway were made: Meal Size a) The OMOE 2015/2016 Guide to Eating Ontario Fish (OMOE 2015) reports an average meal size of 227 grams/meal (for an average adult weighing 70 kg). The Health Canada document "Human Health Risk Assessment of Mercury in Fish and Health Benefits of Fish Consumption" by the Bureau of Chemical Safety and Food Directorate, Health Products and Food Branch, reports an average meal size of 150 grams/meal for Canadian adults consuming finfish. b) the OMOE average meal size of 227 grams/meal was used for adults as it is relevant to Ontario, and is also the meal size used in developing the fish consumption advisories. This value is more conservative than that

Issue Summary	Refinements Made
	reported by Health Canada. In the absence of meal size information for teens, the adult average meal size was adopted (i.e., 227 grams/meal). c) In the absence of meal size information for toddlers and children in the OMOE 2015/2016 Guide to Eating Ontario Fish (OMOE 2015), from which the adult average meal size was obtained, portion sizes for toddlers and children were obtained from the Health Canada (2007) document "Human Health Risk Assessment of Mercury in Fish and Health Benefits of Fish Consumption" by the Bureau of Chemical Safety and Food Directorate, Health Products and Food Branch. The values presented in this document are average meal sizes for children ages 1 to 4 (i.e., toddlers) and ages 5 to 11 consuming finfish, and are 75 grams/meal and 125 grams/meal, respectively. Consumption Frequency and Amortization a) The OMOE (2006) document "2003 Guide to Eating Ontario Sport Fish Questionnaire" summarizes meal frequency for which survey respondents reported consumption of fish caught by angling from Ontario waters. An average frequency of 39 meals/year was reported, with the most common consumption frequency in 2003 being "several times per year" (~22%; this was renamed from "once per 4 months" in the previous survey conducted in 1999), followed by "twice per month" (~18%) and "once per week" (~17%). Approximately 10% of respondents reported consuming more than one meal per week, and about 10% indicated that they only consumed fish during their vacation. Between 1 and 2% of respondents reported consuming fish "never", "once/year" or "daily". Based on this information and based on discussions with OMOE, who have indicated that people fish throughout the year in Ontario, the meal frequency reported by OMOE (2006) appears to be representative of fish consumption throughout the year, rather than concentrated within a limited fishing season. b) The average annual meal frequency reported in OMOE (2006) is similar to the finfish consumption frequencies reported in the Health Canada document "Human Health Risk Assessment of Mercury in Fish and Health Benefits of Fish Consumption" by the Bureau of Chemical Safety and Food Directorate, Health Products and Food Branch (Health Canada 2007). Health Canada provided mean consumption frequencies for Canadian seafood eaters, of 1 ¼ meals per week for adults and <1 meal per week for toddlers (age group 1 to 4 years) and children (age group 5 to 11 years) consuming finfish (sport fish or subsistence consumers).

Issue Summary	Refinements Made
	c) The Health Canada consumption frequency of 1 ¼ meals per week was applied for teens and adults, and an average of one meal per week for toddlers and children, for Canadians consuming finfish. These Health Canada values are consistent with that reported by OMOE (~39 meals per year for adults), and are more conservative (when compared as a weekly average).

7.3.1.4 Summary of Characterization of Potential Receptors, Exposure Frequency and Duration

Receptor characteristics used to evaluate the potential exposure pathways at the site are presented in **Table 13**. The Health Canada (2010a) PQRA Part I Guidance was consulted for standard parameters such as body weight and life stage duration. Rationale for the remaining selected parameters is provided in Section 7.3.1 above.

Recreational users were assumed to include toddlers, children, teens and adults. A toddler (i.e., age 7 months to 4 years) was selected to represent people of all ages for non-carcinogens, as this is the age category which would have the greatest exposure to body weight ratio and thus the highest risk estimate. A composite receptor was used to evaluate cancer risks (i.e., cumulative ILCRs were calculated for the four age groups considered relevant to the site, including toddler, child teen and adult life stages).

For this assessment, it was assumed that any COPC could be a developmental toxicant, and therefore exposure was only amortized over a week (i.e., exposures were treated as chronic exposures). Further details are provided in the Toxicity Assessment (Section 7.4).

Table 13: Receptor Characteristics

	Units	Toddler	Child	Teen	Adult	Source/Rationale
		>6 mo to <5 yr	5-11 yr	12-19 yr	≥20 yr	
GENERAL PARAMETERS						
Body weight	kg	16.5	32.9	59.7	70.7	Health Canada (2010a)
Life stage duration	years	4.5	7	8	60	Health Canada (2010a)
Life expectancy	years	80	80	80	80	Health Canada (2010a)
A. SEDIMENT PATHWAYS						
1) Incidental ingestion of suspended sediments during in-water recreational activities (Shallow Water/Shoreline Scenario)						
Suspended sediment ingestion rate	kg/hr	7.7×10^{-6}	7.7×10^{-6}	7.7×10^{-6}	7.7×10^{-6}	Wilson et al. (2015); rate of 7.7 mg/hour converted to kg/hour (1×10^6 mg per kg)
2) Dermal contact with sediment						
Skin surface area available for contact (feet)	cm^2	430	720	1,080	1,200	Richardson (1997), as cited in Intrinsik (2011)
Sediment to skin adherence factor (feet)	kg/cm^2-event	6.7×10^{-6}	6.7×10^{-6}	6.7×10^{-6}	6.7×10^{-6}	Kissel (1996) dermal adherence factor of 6.7 mg/cm^2 for children's feet, converted to kg/cm^2 (1×10^6 mg per kg)

	Units	Toddler	Child	Teen	Adult	Source/Rationale
		>6 mo to <5 yr	5-11 yr	12-19 yr	≥20 yr	
3) Exposure duration and frequency for sediment pathways						
Events per day	events/ day	1	1	1	1	site-specific assumption; same for all three exposure areas
Event duration - incidental ingestion of surface water	hours/ event	1	1	1	1	site-specific assumption; same for all three exposure areas
Event duration - dermal contact	hours/ day	2	2	2	2	site-specific assumption; same for all three exposure areas; it was assumed that sediment contact would occur for up to one hour, and that sediment could adhere for two hours
Days per week (7 days)						
North Exposure Area of Western KIH	days/ week	1	1	1	1	site-specific assumption
Central Exposure Area of Western KIH	days/ week	1	1	1	1	site-specific assumption
South Exposure Area of Western KIH	days/ week	2	2	2	2	site-specific assumption
Weeks per year (52 weeks; carcinogens only; chemical specific)						
North Exposure Area of Western KIH	weeks/ year	17	17	17	17	site-specific assumption; June through September
Central Exposure Area of Western KIH	weeks/ year	17	17	17	17	site-specific assumption; June through September
South Exposure Area of Western KIH	weeks/ year	17	17	17	17	site-specific assumption; June through September
B. SURFACE WATER PATHWAYS						
1) Incidental ingestion of surface water (Deep Water Scenario)						
Surface water ingestion rate	L/hour	0.05	0.05	0.05	0.05	Dufour et al. (2006), as cited in Wilson et al. (2015), provides a surface water ingestion rate of 50 mL/hour (0.05 L/hour). Assuming 1 hour per event, and 1 event per day (as indicated below for each exposure zone evaluated, this translates to 0.05 L/day)
2) Dermal contact with surface water						
Skin surface area available for contact (whole body)	cm^2	6,130	10,140	15,470	17,640	Health Canada (2010a)

	Units	Toddler	Child	Teen	Adult	Source/Rationale
		>6 mo to <5 yr	5-11 yr	12-19 yr	≥20 yr	
3) Exposure duration and frequency of direct contact with surface water						
Events per day	events/ day	1	1	1	1	site-specific assumption; same for all three exposure areas
Event duration	hours/ event	1	1	1	1	site-specific assumption; same for all three exposure areas
Days per week (7 days)						
North Exposure Area of Western KIH	days/ week	1	1	1	1	site-specific assumption
Central Exposure Area of Western KIH	days/ week	1	1	1	1	site-specific assumption
South Exposure Area of Western KIH	days/ week	2	2	2	2	site-specific assumption
Weeks per year (52 weeks) [carcinogens only; chemical specific]						
North Exposure Area of Western KIH	weeks/ year	17	17	17	17	site-specific assumption; June through September
Central Exposure Area of Western KIH	weeks/ year	17	17	17	17	site-specific assumption; June through September
South Exposure Area of Western KIH	weeks/ year	17	17	17	17	site-specific assumption; June through September
C. FOOD PATHWAYS - FISH INGESTION						
Fish ingestion rate	kg fish/ meal	0.075	0.125	0.227	0.227	toddler and child - Health Canada (2007) average meal size for toddlers and children consuming finfish; teen/adult - OMOE (2015) average meal size for an average adult weighing 70 kg (meal sizes for teens not available in Health Canada [2007] or OMOE [2015]; therefore meal size for teens conservatively assumed to be the same as that for adults)
Exposure Frequency						
Meals per week	meals/ week	1	1	1.25	1.25	Health Canada (2007)
Weeks per year (52 weeks; carcinogens only; chemical specific)	weeks/ year	52	52	52	52	people were assumed to be consuming fish throughout the year; assumption the same for the three exposure areas evaluated

Notes:

> = greater than; ≥ = greater than or equal to; < = less than, cm^2 = square centimetre; kg = kilogram; kg/cm^2 = kilogram per square centimetre; KIH = Kingston Inner Harbour; L = litre; mg = milligram; mo = month, yr = year.

7.3.2 Exposure Concentrations

The sediment, surface water, and fish fillet exposure concentrations used in the risk refinement are provided in **Appendix C – Table 4**. A brief summary is provided below, organized by media.

7.3.2.1 Sediment

For sediment, a 95% upper confidence limit of the mean (UCLM) was calculated for each COPC in each exposure area, and was the statistic used as the exposure concentration in the risk refinement. The sediment exposure concentrations are provided in **Appendix C – Table 4**. The 95% UCLMs were calculated using sediment chemistry data as described below.

- Spatial depictions of surface sediment (0 – 0.15 m) chemistry distributions (for 2003 to 2013 inclusive) were created using an ArcGIS Version 10.3.1 inverse-distance weighting (IDW) interpolation method.
- The IDW creates an estimation of the surface distribution of each chemical using multivariate interpolation of known concentrations of a scattered set of sampling locations.
- The IDW surface was then divided into 5 × 5 m grids and the interpolated concentration of each grid was used to calculate the 95% UCLMs for each COPC within a study area.
- The 95% UCLMs were calculated using US EPA ProUCL software, version 5.0 (US EPA 2013).

7.3.2.2 Surface Water

For surface water, where sufficient data were available, 95% UCLMs were calculated using the US EPA's ProUCL software (version 5.0, US EPA 2013). Where a parameter was detected and insufficient data were available to calculate a 95% UCLM, the 90th percentile was calculated where possible; otherwise the maximum detected concentration was used as the exposure concentration.

Where a parameter was not detected in any of the samples in the area being evaluated (e.g., antimony, arsenic, and several PAHs), half the detection limit was used as the exposure concentration. This approach assumes that on average, all values between the detection limit and zero could be present, and that the average value of non-detects could be as high as half the detection limit. This method is reasonable as it is assumed that it is possible that the COPCs identified in sediment may be present in water at some concentration below the detection limit. Using a half detection limit where data are non-detect is more conservative than the alternate approach of assuming that a non-detect means that the chemical is absent, and more reasonable than assuming that where data are below detection limits, that a COPC is present at the detection limit, which would be a highly conservative approach and would bias risk estimates high.

The surface water exposure concentrations are provided in **Appendix C – Table 4**.

7.3.2.3 Fish

As described in **Table 12** (Section 7.3.1.3), available chemistry data from fillet samples of species consumed by people and collected in Western KIH were pooled, and included perch, largemouth bass and pike (data from RMC-ESG 2014). The fish tissue exposure concentrations are provided in **Appendix C – Table 4**.

Where sufficient data were available, 95% UCLMs were calculated using the US EPA's ProUCL software (version 5.0, US EPA 2013). Where a parameter was not detected, half the detection limit was used as the exposure concentration (refer to *Surface Water* above for rationale).

Five samples were analyzed for arsenic, which were all below the laboratory detection limit. However, the numerical detection limit was not reported by RMC-ESG (2014). For arsenic, the detection limit of these five samples was assumed to be the same as that reported for speciated arsenic (<0.010 mg/kg). As all reported values were non-detect, half the detection limit was used as the exposure concentration.

Total chromium was not analyzed in fish, and the available data are for hexavalent chromium (RMC-ESG 2014).

Five samples were analyzed for lead, three of which were below the laboratory detection limit. However, the numerical detection limit was not reported by RMC-ESG (2014). For lead, the maximum detected concentration was used as the exposure concentration.

7.3.3 Exposure Equations

The exposure equations used in the risk refinement are presented in **Appendix C**, and were obtained from Health Canada (2010a) unless otherwise indicated.

Calculated exposure doses are provided by receptor type in **Appendix C (Tables 5 to 10)**. Sample calculations were also conducted manually to provide an additional check for the model calculations, and are included in **Appendix C**.

7.4 Toxicity Assessment

Toxicity assessment involves identification of the potentially toxic effects of chemicals and determination of the amount of chemicals that can be taken into the body without experiencing adverse health effects. The toxicity assessment provides the basis for evaluating what is an acceptable exposure and what level of exposure may adversely affect people's health. The toxicity assessment provides a measure of the potential for adverse effects to carcinogenic (non-threshold) and non-carcinogenic (threshold) chemicals.

The risk refinement focuses on addressing the gaps and refinements needed based on the FCSAP Expert Support comments provided, and does not include a refinement of the toxicity reference values used in the RMC-ESG (2014) risk assessment, as the toxicity assessment was not identified as requiring refinement based on Health Canada's review, with the exception of lead (see below). For COPCs identified by RMC-ESG and re-evaluated as part of this risk refinement, the TRVs used in the RMC-ESG (2014) risk assessment were checked for updates. The cancer classification, TRVs, mode of action, and oral and dermal relative absorption factors used in the risk refinement are provided in **Appendix C – Table 11**.

Several new COPCs were identified as part of the refined COPC screening, and include aluminum, cobalt, manganese and vanadium. For these COPCs, TRVs were selected preferentially from Health Canada (2010b) if available. Where a Health Canada TRV was not available, TRVs were selected from the US EPA IRIS database (US EPA 2015), the World Health Organization (WHO), the Netherlands National Institute of Public Health and the Environment (RIVM) or, the Agency for Toxic Substances and Disease Registry (ATSDR). A summary of the TRVs used in the risk refinement is included in **Appendix C – Table 11**.

Lead

Health Canada indicated that the Contaminated Sites Division (CSD) of Health Canada currently does not endorse a TRV for lead for use in human health risk assessments at contaminated sites. The previous value in Health Canada's guidance (i.e., a tolerable daily intake [TDI] of 3.6 µg/kgBW-day), is no longer recommended for use within contaminated site risk assessments. Health Canada also no longer recommends the use of the OMOE TDI of 1.85 µg/kg-day, which was the value used in the RMC-ESG (2014) human health risk assessment. Health Canada recommends that risk assessors weigh the available information to arrive at a suitable TRV based on sound professional judgement.

In the absence of a specific recommended value from Health Canada, the TRVs used for lead in the risk refinement were oral reference doses (RfDs) derived by SNC Lavalin for children and adults (SNC Lavalin 2012) as follows:

- For infants, toddlers and children—an oral RfD of 0.6 µg/kgBW-day (approximately equivalent to a blood lead level of 2 µg/dL) based on the daily dose associated with a 1 IQ point decrement in infants, toddlers and children (WHO 2010, 2011, as cited in SNC Lavalin 2012).
- For adults—an oral RfD of 1.3 µg/kgBW-day based on blood pressure effects and protective of women of childbearing age (SNC Lavalin 2012). A daily dose of 1.3 µg/kgBW-day would result in no more than a 1-mmHg increase in average systolic blood pressure (WHO 2011, as cited in SNC Lavalin 2012). To be protective of fetal IQ effects, the daily dose in women of childbearing age that should not result in exceeding a cord blood lead concentration of 2.0 µg/dL is 1.5 µg/kg-day (SNC Lavalin 2012). Therefore, the oral RfD of 1.3 µg/kg-day was selected, as it is protective of both blood pressure effects and effects on the fetus for women who are pregnant or could potentially become pregnant. In the absence of a lead TRV for teens, that for adults was applied to teens.

PCBs

The available sediment and fish tissue data from RMC-ESG (2014) are for total PCBs, and sometimes included a subset of Aroclors (e.g., Aroclor 1254, 1260). Data were not available for dioxin-like PCB congeners, and therefore exposure to dioxin-like PCBs could not be evaluated as part of this assessment.

Although there is information available on dioxin-like PCB congener concentrations in commercial Aroclors (Narquis et al. 2007), from which proportions could be estimated, assuming that the proportions of PCB congeners in commercial Aroclors represent what is present in sediment in Western KIH would be highly uncertain and would result in unreliable risk estimates. In environmental samples, often multiple Aroclor sources with overlapping congeners are present, and natural processes may occur once released into the environment, which may alter the PCB pattern (Naval Facilities Engineering Command 2012). Making an assumption about composition and concentrations of dioxin-like PCBs that may be present would therefore be unreliable. If further information on potential risks from exposure to dioxin-like PCBs is needed, it is recommended that samples are collected and analyzed for the dioxin-like PCB congeners of interest.

Developmental Toxicants and Amortization

Dose averaging was considered on a site- and chemical-specific basis. The anticipated effects of the dose-averaged exposure should remain biologically equivalent to the unadjusted exposure, and need to consider the target organ or form of cancer, mode/mechanism of action, duration of effects, likelihood of exposures during a sensitive life-stage, and whole-body elimination half-life. A summary of this information is provided in **Appendix C – Table 11**.

Health Canada recommends that for developmental toxicants, exposure should not be amortized beyond days per week. There is evidence that inorganic arsenic, lead, mercury and dioxin-like PCBs are developmental toxicants (Equilibrium Environmental Inc. 2009). However, for many of the COPCs identified at the site, mechanisms of toxicity other than the endpoint used to derive the chronic TRV are not clear or are unknown. Many contaminants could cause developmental effects at sufficiently high doses. Therefore, it was conservatively assumed that any of the COPCs could be developmental toxicants, and exposure was not amortized beyond a week, so as to not underestimate exposure for potential developmental effects.

The TRVs used in the risk refinement for threshold contaminants are chronic TRVs and were derived based on long-term and continuous exposures. Based on the observed site conditions and input from Health Canada, continuous daily recreational use of the inner harbour by people was considered to be beyond reasonable expectations. More reasonable, yet conservative and site-specific expectations for site use were for one or two days per week over the summer weather. If people do use the site for the recreational activity assumed in this risk refinement, contaminant exposure would not be continuous, but a pulse exposure (weekly) with several days of depuration prior to an additional pulse exposure. The duration of exposure at KIH is less than that which the TRVs are based on, and it is expected that there would be periods of recovery in between the pulse (weekly exposures) for threshold contaminants.

Mutagenic Carcinogens

For carcinogens known to act via a mutagenic mode of action (i.e., carcinogenic PAHs), risks were estimated for both long-term exposure and for short-term exposure, in order to address concerns about potential exposure during sensitive life stages. Age-dependent adjustment factors (ADAFs) were applied in calculating cumulative ILCRs for short-term exposures, and were taken from Health Canada's recent interim guidance for short-term exposures to carcinogens (toddler [5], child [3], teen [2], adult [1]; Health Canada 2013).

Bioavailability

Assumptions made by RMC-ESG (2014) on bioavailability were not revisited as part of this risk refinement, as Health Canada did not identify any issues with respect to bioavailability. As per RMC-ESG, the bioavailability of COPCs for the ingestion exposure pathway was assumed to be 100%. In the absence of sediment dermal absorption factors, the soil dermal absorption factors (i.e., from Health Canada [2010b] and OMOE [2011]) were applied in the dose estimation calculations for the sediment dermal contact pathway and are summarized in **Appendix C – Table 11**.

7.5 Risk Characterization

For a threshold acting chemical, the risk characterization is expressed as a hazard quotient (HQ), which is the ratio of the estimated dose to the toxicity reference value (TRV) or reference dose. The HQs for a COPC associated with the different pathways of exposure were added to determine the potential risk associated with total exposure to a chemical. In addition, HQs calculated for different COPCs were summed if they have the same mode(s) of action on a target organ.

A risk estimate of 0.2 is considered negligible (Health Canada 2010a). For lead, an HQ of less than or equal to 1.0 was considered acceptable. The IQ effects associated with lead exposure are considered to be non-threshold (SNC Lavalin 2012). The TRVs for lead were determined using the slope factors from relevant dose-response analyses rather than from no-observed-adverse-effect-levels (NOAELs) or lowest observed-adverse-effect-levels (LOAELs). Therefore, SNC Lavalin (2012) has been recommended that the lead TRV be applied to risk assessment without consideration of a soil allocation factor less than 1.0.

Due to the conservative nature of the assumptions applied in the calculations, HQs greater than 0.2 (or 1.0 for lead) do not necessarily mean risks are unacceptable; however, it would indicate that further assessment may be required.

For a non-threshold acting chemical, the risk characterization is expressed as an incremental lifetime cancer risk (ILCR), which is calculated as the estimated dose multiplied by TRV or slope factor. Health Canada (2010a) considers one in one hundred thousand (1×10^{-5}) as an acceptable ILCR. An ILCR of less than 1×10^{-5} is considered essentially negligible (Health Canada 2010a). An ILCR greater than 1×10^{-5} is indicative of a potential health concern that should be examined more closely.

7.5.1 Results

7.5.1.1 Non-Carcinogens

Health risks were evaluated for potential human recreational users (toddlers, children, teens and adults) at the Site. For non-carcinogens, a summary of total HQs for the shallow water and deep water scenarios and each COPC are summarized for the toddler in **Table 14**. An assessment of uncertainty and conservatism in the risk refinement is summarized in Section 7.5.2.

Based on the exposure assumptions used, calculated HQs were above the acceptable level for mercury and PCBs for the toddler for both the shallow water/shoreline scenario and deep water scenario. The risks for these two COPCs were driven by the fish ingestion pathway.

A breakdown of the contributions of HQs via sediment ingestion and dermal contact, surface water ingestion and dermal contact and fish ingestion is provided in **Appendix C – Table 6**. COPCs with HQs greater than the target of 0.2 are discussed further below.

- **Mercury**: an HQ of 0.62 was identified for the toddler for both shallow water/shoreline and deep water scenarios in all three Western KIH exposure areas evaluated. The HQs were driven by the fish ingestion pathway, which was based on exposure to methylmercury.
- **Total PCBs**: an HQ of 1.0 was identified for the toddler for both shallow and deep water scenarios in all three Western KIH exposure areas evaluated. The HQs were driven by the fish ingestion pathway. As indicated in Section 7.4, in the absence of congener-specific dioxin-like PCB data, it was not possible to estimate risks for dioxin-like PCBs.

Table 14: Hazard Quotients for the Toddler

Scenario	Shallow Water/Shoreline Scenario			Deep Water Scenario		
Western KIH Exposure Area	**North**	**Central**	**South**	**North**	**Central**	**South**
Metals						
Aluminum	1.4E-03	2.0E-03	2.6E-03	NA[2]	NA[2]	NA[2]
Antimony	1.4E-02	1.5E-02	2.6E-02	6.1E-03	6.1E-03	1.2E-02
Arsenic	1.6E-02	4.2E-02	2.6E-02	1.3E-02	1.3E-02	1.6E-02
Chromium	1.5E-01	1.4E-01	1.4E-01	7.3E-02	7.2E-02	7.2E-02
Cobalt	NA[1]	2.2E-03	NA[1]	NA[2]	NA[2]	NA[2]
Lead	6.1E-01	4.7E-01	4.8E-01	5.9E-01	4.5E-01	4.4E-01
Manganese	3.5E-04	5.5E-04	8.7E-04	NA[2]	NA[2]	NA[2]
Mercury (as methylmercury in fish)	**6.2E-01**	**6.2E-01**	**6.2E-01**	**6.1E-01**	**6.1E-01**	**6.1E-01**
Vanadium	1.9E-03	3.0E-03	4.3E-03	NA[2]	NA[2]	NA[2]
Organics						
Total PCBs	**1.0E+00**	**1.0E+00**	**1.0E+00**	**1.0E+00**	**1.0E+00**	**1.0E+00**

Notes:

KIH = Kingston Inner Harbour; NA = not applicable; PCBs = polychlorinated biphenyls.

1 – Cobalt was not identified as a COPC in the north and south exposure areas of Western KIH.

2 – Not measured in surface water; therefore exposure from this pathway could not be estimated.

Bold and shaded cells indicate a hazard quotient greater than 0.2 (or 1.0 for lead).

Comparison of Fish Tissue Concentrations in Western KIH to Reference Area

For mercury and PCBs, fish ingestion was the driving pathway for non-carcinogenic risks.

The total PCB concentrations in fillets of largemouth bass, northern pike and yellow perch sampled in Western KIH were used to estimate the total PCB exposure concentration, which was a 95% UCLM of 0.2 mg/kg wet weight. Fillet data for these same fish species from reference areas were not available for total PCBs. The total PCB concentrations in whole fish and partial fish from reference areas ranged from 0.017 to 0.15 mg/kg wet weight. The 95% UCLM of total PCBs in fillets of relevant species of fish collected from the exposure area (Western KIH) was greater than the range observed in the reference area.

The methylmercury concentrations in fillets of largemouth bass, northern pike and yellow perch sampled in Western KIH were used to estimate the methylmercury exposure concentration, which was a 95% UCLM of 0.19 mg/kg wet weight. Fillet data for these same fish species from reference areas were not available for methylmercury. The methylmercury concentrations in whole fish from reference areas ranged from 0.05 to 0.13 mg/kg wet weight. The 95% UCLM of methylmercury in fillets of relevant species of fish collected from the exposure area was greater than the range observed in the reference area.

Fish Consumption Advisories

There are currently fish consumption advisories for these COPCs in the Cataraqui River, Belle Island Area in Leeds County (OMOE 2015). The fish consumption advisories for mercury are for largemouth bass, northern pike and walleye. The fish consumption advisories for PCBs are for black crappie, bluegill sunfish, brown bullhead, common carp, largemouth bass, northern pike, walleye and white sucker. **Table 15** summarizes the recommended monthly consumption for fish species considered in the human health risk refinement.

There is also fish consumption advisory for yellow perch due to chromium, but risks from chromium exposure were below the acceptable level (**Table 14 Appendix C – Table 6**).

Table 15: Recommended Fish Consumption of Fish Containing Mercury and Polychlorinated Biphenyls

Fish Species	Fish Length (cm)	Recommended Consumption[1] (meals/month)	
		General Population	Sensitive[2] Population
Largemouth bass	15 to 35	8	8
	35 to 45	4	4
Northern pike	40 to 65	8	8
	65 to 75	8	4

Notes:

1 – Based on an average meal of 227 g for a 70 kg adult.

2 – Women of child-bearing age or children under 15 years.

7.5.1.2 Carcinogens

For carcinogens, ILCRs for the shallow water/shoreline and deep water scenarios and each COPC are summarized for the composite receptor (sum of risks for toddler, child, teen and adult) in **Table 16**. For non-threshold carcinogens acting through a mutagenic mode of action, as recommended by Health Canada (2013), age dependent adjustment factors (ADAFs) were applied to account for the sensitivity of the age-dependent exposure period. These results are also presented in **Table 16** (Short-term Carcinogenic Exposure to PAHs).

Based on the exposure assumptions employed, calculated long-term ILCRs for the composite receptor were above the acceptable level for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-c,d)pyrene and the sum of carcinogenic PAHs in all three Western KIH exposure areas evaluated under the shallow water/shoreline scenario. The calculated short-term ILCRs for the composite receptor were above the acceptable level for the same PAHs with the exception of chrysene, which exceeded the acceptable level in the northern exposure area of Western KIH. The ILCRs were below the acceptable level in the deep water scenario, where dermal exposure to bedded sediments was not assumed to occur.

Table 16: Incremental Lifetime Cancer Risks for the Composite Receptor

Scenario	Shallow Water/Shoreline Scenario			Deep Water Scenario		
Western KIH Exposure Area	**North**	**Central**	**South**	**North**	**Central**	**South**
Metals						
Arsenic	5.6E-06	7.9E-06	6.4E-06	5.4E-06	5.4E-06	5.5E-06
Long-term Exposure to Carcinogenic PAHs						
Benzo(a)anthracene	**3.2E-05**	**6.9E-05**	**5.5E-05**	2.0E-10	2.0E-10	3.9E-10
Benzo(a)pyrene	**4.1E-04**	**7.1E-04**	**6.1E-04**	9.9E-11	9.9E-11	2.0E-10
Benzo(b)fluoranthene	**1.9E-05**	**6.8E-05**	**6.6E-05**	9.9E-11	9.9E-11	2.0E-10
Benzo(g,h,i)perylene	3.0E-06	4.1E-06	4.1E-06	2.0E-11	2.0E-11	3.9E-11
Benzo(j)fluoranthene	**8.9E-05**	**8.9E-05**	**1.1E-04**	NA[1]	NA[1]	NA[1]
Benzo(k)fluoranthene	**2.2E-05**	**3.2E-05**	**3.9E-05**	9.9E-11	9.9E-11	2.0E-10
Chrysene	9.3E-06	7.2E-06	5.2E-06	9.9E-12	9.9E-12	2.0E-11
Dibenzo(a,h)anthracene	**9.8E-05**	**1.1E-04**	**1.3E-04**	2.0E-09	2.0E-09	3.9E-09
Indeno(1,2,3-c,d)pyrene	**5.4E-05**	**4.6E-05**	**4.6E-05**	2.0E-10	2.0E-10	3.9E-10
Total Carcinogenic PAHs	**7.3E-04**	**1.1E-03**	**1.1E-03**	2.7E-09	2.7E-09	5.4E-09
Short-term Exposure to Carcinogenic PAHs[2]						
Benzo(a)anthracene	**4.1E-05**	**9.0E-05**	**7.1E-05**	4.2E-10	4.2E-10	8.4E-10
Benzo(a)pyrene	**5.3E-04**	**9.3E-04**	**7.9E-04**	2.1E-10	2.1E-10	4.2E-10
Benzo(b)fluoranthene	**2.4E-05**	**8.9E-05**	**8.5E-05**	2.1E-10	2.1E-10	4.2E-10
Benzo(g,h,i)perylene	3.9E-06	5.4E-06	5.4E-06	4.2E-11	4.2E-11	8.4E-11
Benzo(j)fluoranthene	**1.2E-04**	**1.2E-04**	**1.4E-04**	NA[1]	NA[1]	NA[1]
Benzo(k)fluoranthene	**2.8E-05**	**4.1E-05**	**5.1E-05**	2.1E-10	2.1E-10	4.2E-10
Chrysene	**1.2E-05**	9.4E-06	6.8E-06	2.1E-11	2.1E-11	4.2E-11
Dibenzo(a,h)anthracene	**1.3E-04**	**1.5E-04**	**1.6E-04**	4.2E-09	4.2E-09	8.4E-09
Indeno(1,2,3-c,d)pyrene	**7.1E-05**	**6.0E-05**	**6.0E-05**	4.2E-10	4.2E-10	8.4E-10
Total Carcinogenic PAHs	**9.6E-04**	**1.5E-03**	**1.4E-03**	5.7E-09	5.7E-09	1.1E-08

Notes:

KIH = Kingston Inner Harbour; PAH = polycyclic aromatic hydrocarbon.

1 – Not measured in surface water; therefore exposure from this pathway could not be estimated.

2 – Short-term carcinogenic exposure to PAHs including the age-dependent adjustment factor for life stage.

Bold and shaded cells indicate an incremental lifetime cancer risk greater than 1×10^{-5}.

A breakdown of the contributions of ILCRs via sediment ingestion and dermal contact, surface water ingestion and dermal contact and fish ingestion is provided in **Appendix C – Tables 6 to 9**. COPCs with ILCRs greater than the acceptable level of 1 × 10^{-5} are discussed further below.

- **Total Carcinogenic PAHs in the Shallow Water/Shoreline Scenario**: the cumulative long-term ILCRs for the North, Central and South exposure areas of Western KIH were 7.3 × 10^{-4}, 1.1 × 10^{-3} and 1.1 × 10^{-3}, respectively. The cumulative short-term ILCRs for the North, Central and South exposure areas of Western KIH were 9.6 × 10^{-4}, 1.5 × 10^{-3} and 1.4 × 10^{-3}, respectively. The ILCRs were driven by the dermal contact with sediment pathway.

7.5.1.3 Contaminants of Potential Concern Acting on the Same Target Organ

When more than one COPCs exhibit similar critical effects or act on the same target organ, via the same mode or mechanism of action, the risk estimates for these COPCs are generally summed to provide a risk estimate by target organ/critical effect. Information on target organ/system and mode of action is provided in **Appendix C – Table 11**.

Both methylmercury and PCBs target the nervous system and may work synergistically to induce neurological effects (Beamis and Seegal 1999, as cited in Van Oostam et al. 2005). These two COPCs were summed to determine the overall effect on the nervous system and are presented in **Table 17** for the toddler and teen.

Table 17: Hazard Quotients by Target Organ/Critical Effects for the Toddler and Teen

COPCs	Target Organ/System	Toddler			Teen		
		North	Central	South	North	Central	South
Shallow Water/Shoreline Scenario							
Methylmercury, Total PCBs	Nervous system	**1.6E+00**	**1.6E+00**	**1.6E+00**	**1.3E+00**	**1.3E+00**	**1.3E+00**
Deep Water Scenario							
Methylmercury, Total PCBs	Nervous system	**1.6E+00**	**1.6E+00**	**1.6E+00**	**1.3E+00**	**1.3E+00**	**1.3E+00**

Notes:

COPC = contaminant of potential concern; HQ = hazard quotient; NA = not applicable; total PCBs = total polychlorinated biphenyls

7.5.1.4 Comparison to RMC-ESG (2014) Results

A comparison of the risks estimated by RMC-ESG (2014) and the current risks based on the refinements made in this assessment is provided below for non-carcinogens and carcinogens. Overall, risks related to the sediment dermal contact pathway are lower than those estimated by RMC-ESG based on the refinements to exposure concentrations, exposure frequency and loading rates. In some cases, the pathways evaluated are different than those evaluated by RMC-ESG (e.g., an evaluation of the fish consumption pathway for several COPCs).

Non-carcinogenic Risk Estimates

RMC-ESG (2014) identified HQs greater than the acceptable level for arsenic, mercury, lead, antimony and PCBs. In this risk refinement, Golder identified HQs greater than the acceptable level only for mercury and PCBs. Comparisons of the non-carcinogenic RMC-ESG (2014) risk estimates to the risk refinement risk estimates for the toddler are presented in **Table 18**.

Table 18: Comparison of Total Hazard Quotients for the Toddler from RMC-ESG and the Current Risk Refinement

COPC	RMC-ESG (2014) HQ	Risk Refinement HQ[1]	Comparison
Aluminum	NA[2]	2.6E-03	Aluminum was retained as a COPC in the risk refinement based on exceedances of the selected sediment screening value; the HQs were below the acceptable hazard quotient of 0.2.
Antimony	1.3E+00	1.4E-02	Risks from exposure to antimony were acceptable in the risk refinement (HQ < 0.2). RMC-ESG (2014) indicated that dermal contact with sediment and sediment ingestion amounted to 82% and 18% of the antimony HQ, respectively. These same pathways made up 10% and 3% of the total HQ in the risk refinement. The exposure dose from dermal contact with sediment was lower because of several refinements made in the risk refinement, to exposure concentrations, exposure frequency and duration assumptions, and dermal adherence factors.
Arsenic	8.0E-01	4.2E-02	Risks from exposure to arsenic were acceptable in the risk refinement (HQ < 0.2). RMC-ESG (2014) indicated that dermal contact with sediment and sediment ingestion amounted to 58% and 42% of the arsenic HQ, respectively. These same pathways made up 33% and 35% of the total HQ in the risk refinement. The exposure dose from dermal contact with sediment was lower because of several refinements made in the risk refinement, to exposure concentrations, exposure frequency and duration assumptions, and dermal adherence factors.
Chromium	1.9E-02	7.4E-02	Risks from exposure to chromium were acceptable in the risk refinement (HQ < 0.2). The risk refinement HQ for chromium was higher than that estimated by RMC-ESG (2014). In the risk refinement, fish ingestion made up 100% of the total HQ, but did not contribute to the RMC-ESG (2014) HQ, as fish consumption was not assessed for chromium.
Cobalt	NA[2]	2.2E-03	Cobalt was retained as a COPC in the risk refinement based on exceedances of the selected sediment screening value. Risks from exposure to cobalt were acceptable in the risk refinement (HQ < 0.2).
Copper	4.4E-03	NA[2]	Copper was not retained as a COPC in the risk refinement because concentrations were below the selected sediment screening value.
Lead	2.8E-01	6.1E-01	The risk refinement HQ for lead was higher than that estimated by RMC-ESG (2014), but was acceptable based on an acceptable HQ of 1.0 for lead. The TRV for lead was updated in the risk refinement. In the risk refinement, fish ingestion was the pathway with the highest contribution to the total HQ, but did not contribute to the RMC-ESG (2014) HQ, as fish consumption was not assessed for lead.
Manganese	NA[2]	8.7E-04	Manganese was retained as a COPC in the risk refinement based on exceedances of the selected sediment screening value. Risks from exposure to manganese were acceptable in the risk refinement (HQ < 0.2).
Mercury	5.6E-01	6.2E-01	The risk refinement HQ for mercury was similar to that estimated by RMC-ESG (2014). In the risk refinement, fish ingestion made up 100% of the total HQ (methylmercury), but did not contribute to the RMC-ESG (2014) HQ, as fish consumption was not assessed for mercury.
Vanadium	NA[2]	4.3E-03	Vanadium was retained as a COPC in the risk refinement based on exceedances of the selected sediment screening value. Risks from exposure to vanadium were acceptable in the risk refinement (HQ < 0.2).
Zinc	4.9E-03	NA[2]	Zinc was not retained as a COPC in the risk refinement because concentrations were below the selected sediment screening value.

COPC	RMC-ESG (2014) HQ	Risk Refinement HQ[1]	Comparison
Chlordane	1.6E-03	NA[2]	Chlordane was not retained as a COPC in the risk refinement because concentrations were below detection limits in all samples analyzed and below the selected sediment screening value.
DDT	9.8E-06	NA[2]	DDT was not retained as a COPC in the risk refinement because concentrations were below detection limits in all samples analyzed and below the selected sediment screening value.
PCBs	1.0E+00	1.0E+00	The total PCB HQ in the risk refinement was the same as that estimated by RMC-ESG (2014). RMC-ESG (2014) indicated that fish ingestion, dermal contact with sediment, sediment ingestion amounted to 89%, 10% and 1% of the total PCB HQ, respectively. The fish ingestion pathway made up 100% of the total HQ in the risk refinement. The exposure dose from dermal contact with sediment was lower because of several refinements made in the risk refinement, to exposure concentrations, exposure frequency and duration assumptions, and dermal adherence factors.
Naphthalene	3.0E-03	NA[2]	Naphthalene was not retained as a COPC in the risk refinement because concentrations were below the selected sediment screening value.
Pyrene	2.0E-03	NA[2]	Pyrene was not retained as a COPC in the risk refinement because concentrations were below the selected sediment screening value.

Notes:
COPC = contaminant of potential concern; HQ = hazard quotient; NA = not applicable.
1 – The highest HQ from the Western KIH exposure area shallow water/shoreline scenario is shown.
2 – Not identified as a COPC.

Carcinogenic Risk Estimates

RMC-ESG (2014) evaluated carcinogenic risks to the composite receptor based on the same exposure pathways listed above. RMC-ESG (2014) identified ILCRs greater than 1×10^{-5} for arsenic and carcinogenic PAHs. Comparisons of the carcinogenic RMC-ESG risk estimates to the risk refinement ILCR estimates for the composite receptor are presented **Table 19**.

7.5.2 Uncertainties

This assessment of potential risk to recreational receptors at the Site was evaluated using generally conservative assumptions (e.g., exposure assumptions, TRVs and relative bioavailability factors). **Table 20** below outlines the sources of uncertainty for the human health risk assessment.

Table 19: Comparison of Total Incremental Lifetime Cancer Risks for a Composite Receptor from RMC-ESG and the Risk Refinement

COPC	RMC-ESG ILCR	Risk Refinement ILCR[1]	Comparison
Arsenic	8.0E-05	7.9E-06	Risks from exposure to arsenic were acceptable in the risk refinement (ILCR < 1 × 10^{-5}). The ILCR calculated in the risk refinement was about an order of magnitude lower than that estimated by RMC-ESG (2014). The risk refinement included an evaluation of fish ingestion. The exposure dose from dermal contact with sediment was lower because of several refinements made in the risk refinement, to exposure concentrations, exposure frequency and duration assumptions, and dermal adherence factors.
Total Carcinogenic PAHs	4.0E-02	1.1E-03	The risk refinement ILCR is lower than that estimated by RMC-ESG (2014), but both exceed the acceptable level of 1 × 10^{-5}. The exposure dose from dermal contact with sediment was lower because of several refinements made in the risk refinement, to exposure concentrations, exposure frequency and duration assumptions, and dermal adherence factors.

Notes:

COPC = contaminant of potential concern; ILCR = incremental lifetime cancer risk.

1 – The highest ILCR from the Western KIH exposure area shallow water scenario is shown, for long-term exposure risks for comparison purposes.

2 – The composite receptor includes the sum of risks for the toddler, child, teen and adult (the four age groups considered relevant to the site).

Table 20: Evaluation of Uncertainty in the Human Health Risk Assessment

Area of Uncertainty	Uncertainty	Under/Overestimate of Risk	Rationale
Exposure Assumptions			
Use of 95% UCLM sediment concentrations of COPCs to estimate risks	Low	Neutral	The 95% UCLM for each COPC was calculated from an inverse distance weighted (IDW) interpolation method as described in Section 3.1 and 7.3.2.1. Using a 95% UCLM concentration and this method would result in reasonable exposure concentrations and is not likely to under or overestimate risks.
Use of maximum surface water and fish concentrations of COPCs to estimate risks	Moderate	Overestimate	Insufficient data were available to calculate a 95% UCLM or 90th percentile for some COPCs; therefore, the maximum concentration was used as the exposure concentration (e.g., for lead in fish), which is a conservative approach.
Body weights, ingestion rates, skin surface areas, sediment adherence factors	Low to High	Over estimate	Body weights and whole body skin surface areas were based on average Canadian exposure characteristics (Health Canada 2010a), and uncertainty associated with these parameters is low, and on their own would have a neutral impact on estimate of risk. In the absence of values from Health Canada guidance, several sources were consulted for receptor characteristics related to sediment dermal adherence, and water ingestion rates.

Area of Uncertainty	Uncertainty	Under/Overestimate of Risk	Rationale
			These include the following: ▪ suspended sediment and surface water ingestion rates based on a study by Wilson et al. (2015) ▪ skin surface area of feet based on Richardson (1997, as cited in Intrinsik 2011) ▪ sediment adherence factors based on a study by Kissel (1996) ▪ fish ingestion rates for the toddler and child obtained from Health Canada (2007) and for the teen and adult from OMOE (2015). Of these, the **sediment adherence factors** have the highest uncertainty and likely result in an overestimate of risks from dermal exposure. There are no known sediment loading factors that have been published for exposure to bedded sediments under a swimming/wading scenario, and the rates used in this assessment were for exposed shoreline mud, and were selected based on the importance of comparing the expected exposure condition with that of the experimental study used to derive absorption estimates. The conditions/exposure scenario at the site do not fall clearly into any of the categories for which dermal sediment adherence factors are available (see Section 7.3.1.1). The rates used do not account for any washing of sediments that may occur as people swim or walk through the water.
Exposure frequency – water and sediment	Low to Moderate	Overestimate	Based on the natural characteristics and accessibility of the Western KIH shoreline, and the presence of weed-like plants in the water, recreational use is expected to be only incidental (very occasional). However, in an attempt to provide useful estimates of risks to support risk management, it was assumed that someone may be recreationally using the shoreline on a weekly basis. Based on the likelihood that site use is infrequent, risks are likely overestimated, and considering that it is assumed that a person would be recreating in Western KIH over their lifetime.
Sediment exposure duration	Low	Potential underestimate	It was assumed that sediment exposure would occur for a total of two hours per day (1 hour for dermal contact during swimming and an additional hour under the assumption that people would not wash off their feet immediately after exposure). This was considered reasonable because: 1) there are no beach-like areas where people would be exposed directly to exposed sediment for an extended period; 2) exposure to sediment is with submerged, bedded sediment and it is expected that sediment would wash off as people moved through or swim in the water and when they exit the water; 3) it was assumed that people would clean their feet following recreational activities. In the event that sediment is not completely washed

Area of Uncertainty	Uncertainty	Under/Overestimate of Risk	Rationale
			off, risk estimates were recalculated without the 2 hour/24 hour exposure term. The HQs increased, but are below the threshold of 0.2 for all COPCs except mercury and total PCBs, which is consistent with the original results. The cumulative ILCRs increased above the risk threshold of 1 in 100,000 for arsenic (central and south exposure areas), benzo(g,h,i)perylene (all exposure areas) and chrysene (all exposure areas).
Fish ingestion	Moderate	Overestimate	It was assumed that people were consuming fish only from Western KIH, and for a lifetime, which is highly conservative.
Lack of PAH data for fish	Moderate	Neutral	PAH data were not available for fish (i.e., PAHs were not measured in fish), PAHs tend not to bioaccumulate in fish and therefore high concentrations would not be expected in muscle tissues.
Methods used to estimate dermal exposure to carcinogenic PAHs	High	Overestimate	There are no methods that would allow a realistic approach to estimating dermal exposure to sediments. Based on the available methods, dermal exposure to bedded sediments is likely overestimated. This is due in part to the dermal sediment loading factors (see above) and also to the skin thickness adjustment to account for differences in human and mouse skin thickness. The skin thickness used in estimating human health risks is likely thinner than the actual thickness of the skin on the bottom of human feet.
Dermal RAFs for PAHs	Moderate	Overestimate	Dermal RAFs for sediment are not available, and the dermal RAF used in the assessment of carcinogenic PAHs was for soil (14.8%; Health Canada 2010b). As indicated by RMC-ESG (2014), the assumption that the dermal RAF for PAHs is as high as 14.8% is an uncertainty, and likely results in an overestimate of risk, because for weathered PAHs in both sandy and clay soils, the RAF has not been reported to be higher than 4.4% (Knafla et al. 2011; as cited in RMC-ESG 2014).
Toxicity Assessment			
Toxicity Reference Values (Non-Carcinogens)	Low (based on humans) to high (based on animals)	Overestimate	Toxicity data are based on sensitive endpoints. Uncertainty and safety factors are applied to account for inter and intra species variability.
Toxicity Reference Values (Carcinogens)	Low (based on humans) to high (based on animals)	Overestimate	Toxicity data are based on sensitive endpoints. High dose to low dose extrapolation methods are typically conservative.
Relative Bioavailability Factors	Low to moderate	Overestimate	Based on chemical specific data and assumes bioavailability from soil is equivalent to exposure in the toxicity study used to derive the TRV.

7.5.3 Overall Summary

General definitions for the potential magnitude of risk associated with HQ and ILCR results are provided in **Table 21**. These criteria, which were applied for both human and wildlife health assessments, provide ranges of HQs and ILCRs used to categorize the potential magnitude of risk. The category names of low, moderate, and high are not intended to convey the overall determinations of risk or environmental significance, which can only be made once the uncertainties and conservatism in the analyses have been evaluated.

Table 21: Criteria Used to Assess Magnitude of Potential Risk for Human Health

Parameter	Levels of Magnitude of Potential Risk			
	Negligible	Low	Moderate	High
Non-Carcinogenic Substances	HQ ≤ 0.2	0.2 < HQ ≤ 1	1 < HQ ≤ 10	HQ > 10
Carcinogenic Substances	ILCR ≤ 1 × 10^{-5}	1×10^{-5} < ILCR ≤ 1 × 10^{-4}	1 × 10^{-5} < ILCR ≤ 1 × 10^{-4}	ILCR > 1 × 10^{-4}

Notes:

≤ = less than or equal to; < = less than; > = greater than; HQ = hazard quotient (represents the target ratio of the predicted chemical exposure relative to its health-based benchmarks); ILCR = incremental lifetime cancer risk (additional or extra risk of developing cancer due to exposure to a chemical [from the site] incurred over the lifetime of an individual)

Table 22 presents an overall summary of risks for COPCs that had risk estimates exceeding acceptable levels as defined by Health Canada (2010a), based on consideration of the magnitude of the risk estimate, and the uncertainties and conservatism in the estimate of risk (as described in Section 7.5.2). For example, the magnitude of the risk estimate for carcinogenic PAHs was high in all three exposure areas (it fell into the ILCR > 1 × 10^{-4} category), but based on the uncertainties and conservatism identified in Section 7.5.2, and particularly related to dermal uptake and the uncertainty in estimating dermal risks from exposure to sediment, the overall risks from dermal exposure to carcinogenic PAHs in bedded sediments along the western shoreline in KIH is expected to be low to moderate.

For non-carcinogens (i.e., methylmercury and PCBs), the magnitude of risk is based on the most conservative receptor, the toddler. For carcinogens, the magnitude of risk is based on a composite receptor (sum of risks over a lifetime from toddler to adult for this assessment).

Table 22: Overall Summary of Risks

Area of Western KIH	COPC	Magnitude of Risk Estimate	Key Exposure Pathway/Risk Driver	Uncertainty	Conservatism	Strength of Risk Estimate	Overall Risk Rating
North	Methylmercury	Low	Fish ingestion	Moderate	Moderate to High	Moderate	**Low**
	Total PCBs	Low	Fish ingestion	Moderate	Moderate to High	Moderate	**Low**
	Carcinogenic PAHs	High	Dermal contact with sediment (shoreline/shallow water scenario)	High	High	Low	**Low to Moderate**
Central	Methylmercury	Low	Fish ingestion	Moderate	Moderate to High	Moderate	**Low**
	Total PCBs	Low	Fish ingestion	Moderate	Moderate to High	Moderate	**Low**
	Carcinogenic PAHs	High	Dermal contact with sediment (shoreline/shallow water scenario)	High	High	Low	**Low to Moderate**
South	Methylmercury	Low	Fish ingestion	Moderate	Moderate to High	Moderate	**Low**
	Total PCBs	Low	Fish ingestion	Moderate	Moderate to High	Moderate	**Low**
	Carcinogenic PAHs	High	Dermal contact with sediment (shoreline/shallow water scenario)	High	High	Low	**Low to Moderate**

8.0 WEIGHT OF EVIDENCE INTEGRATION

Results of the aquatic, wildlife, and human health risk assessments are presented in **Figure 21** and presented in **Table 23** below. Because the various receptors have different uncertainties, and varying importance to different stakeholders, we have not attempted to numerically synthesize the results from different receptors (invertebrates, fish, birds, mammals, human health). We have not summarized risk to amphibians or reptiles in this section due mainly to the high uncertainty in the risk characterization for this receptor group; however, the risks to other receptor groups identified for several shoreline management units could be increased for the habitats that contain herptiles.

The weight of evidence indicates several key findings of relevance to site management:

- Moderate magnitude ecological risks were identified in the Parks Canada water lot, particularly in the areas adjacent to Orchard Street Marsh and the unnamed creek that enters KIH. Although few indications of harm were documented for the benthic community, moderate risks to bottom fish (elevated risk of deformities primarily from PAH contamination), birds (moderate risks to omnivorous birds such as mallards and marsh wrens due to chromium contamination), and risks to mammals (PCB risk to resident mink) were all identified for the areas close to the shoreline (i.e., management units PC-W and TC-OM).
- Significant ecological risks were identified for the south portion of KIH including Anglin Bay and vicinity. However, the risk pathways were different for this area, with risks greatest to the benthic community and bottom fish from exposure to PAHs.
- Some areas in KIH were identified to have low overall risks relative to adjacent management units (e.g., TC-1, which covers a large area of the Transport Canada water lot, but yields negligible to low risk outcomes for all receptors. This helps to prioritize management on areas with multiple elevated risk levels.
- Multiple drivers for elevated risks were identified, with PAHs, PCBs, and chromium driving the highest ecological risks, and PAHs, PCBs, and mercury driving the human health risks. The contaminants are often coincident (e.g., PC-W contains among the highest concentrations of all of these substances). However, in some portions of KIH, the concentrations distributions do not align; for example PAH and PCB concentration distributions in the central portion of the harbour are different.
- Human health risks above acceptable levels were identified for multiple constituents, yielding moderate risk for the sediment exposure pathway (i.e., dermal contact from scenarios entailing recreation within the nearshore sediments) and low risk for the fish consumption pathway. The constituents driving these risks are primarily carcinogenic PAHs for the sediment exposure pathway, but mercury and PCBs for the fish consumption pathway. These constituents have different concentration distribution patterns across KIH.
- Although risks to herptiles could not be quantified or categorized with the same level of confidence as other receptors, it is evident that the areas with suitable habitat for these organisms (e.g., management units PC-E, PC-W, and TC-OM) already have moderate ecological risks as identified for other organisms. As such, risk management or remediation to address other risk pathways will contribute to the management of herptile populations. An added consideration is that physical intervention in the wetland areas of KIH, while of benefit for reducing risks for some pathways, will have potentially significant consequence for the habitat of amphibians and reptiles. In addition to the Parks Canada wetland and riparian zones, habitat for herptiles has also been observed along the western shoreline of KIH, including parts of Douglas Fluhrer Park.

The next stage of investigation will entail an evaluation of remedial options.

This will entail:

- An evaluation of the risk magnitude and uncertainties associated with the various risk characterization outcomes shown in **Figure 21;**
- Consideration of the protection goals for site management (i.e., balancing the costs and benefits of reducing risks to different receptor types);
- Consideration of where significant risk pathways overlap (i.e., where management for one substance influences the risk of another substance; and
- Consideration of efficiency in risk reduction (i.e., level of effort or sediment volumes required to meaningfully reduce risks).

Table 23: Integrated Results of the Aquatic, Wildlife and Human Health Risk Assessments

<table>
<tr><th rowspan="2">Unit</th><th colspan="4">Ecological Receptors</th><th colspan="2">Human Health</th></tr>
<tr><th>Effects to Benthic Community</th><th>Effects to Fish Health</th><th>Effects to Birds</th><th>Effects to Mammals</th><th>Risks from Sediment Exposure</th><th>Risks from Fish Consumption</th></tr>
<tr><td>PC-N</td><td>Negligible Risk</td><td>Negligible Risk</td><td>Negligible Risk</td><td>Negligible Risk</td><td>NA</td><td rowspan="15">Low Risk</td></tr>
<tr><td>TC-E</td><td>Negligible Risk</td><td>Negligible Risk</td><td>Negligible Risk</td><td>Negligible Risk</td><td>NA</td></tr>
<tr><td>PC-E</td><td>Negligible Risk</td><td rowspan="3">Moderate Risk</td><td>Moderate Risk</td><td>Low Risk</td><td rowspan="3">Moderate Risk</td></tr>
<tr><td>PC-W</td><td>Negligible Risk</td><td>Moderate Risk</td><td>Moderate Risk</td></tr>
<tr><td>TC-OM</td><td>Negligible Risk</td><td>Moderate Risk</td><td>Moderate Risk</td></tr>
<tr><td>TC-1</td><td>Negligible Risk</td><td rowspan="2">Low to Moderate Risk</td><td rowspan="2">Low Risk</td><td rowspan="10">NA</td><td>NA</td></tr>
<tr><td>TC-RC</td><td>Negligible Risk</td><td rowspan="2">Moderate Risk</td></tr>
<tr><td>WM</td><td>Negligible Risk</td><td rowspan="4">Low to Moderate Risk</td><td rowspan="3">Negligible Risk</td></tr>
<tr><td>TC-2B</td><td>Moderate Risk</td><td>NA</td></tr>
<tr><td>TC-2A</td><td>Moderate Risk</td><td rowspan="2">Moderate Risk</td></tr>
<tr><td>TC-3A</td><td>Negligible Risk</td><td rowspan="3">Negligible Risk</td></tr>
<tr><td>TC-3B</td><td>Moderate Risk</td><td>NA</td></tr>
<tr><td>TC-4</td><td>High Risk</td><td rowspan="3">Moderate Risk</td><td rowspan="2">Moderate Risk</td></tr>
<tr><td>TC-AB</td><td>High Risk</td><td rowspan="2">Negligible Risk</td></tr>
<tr><td>TC-5</td><td>Moderate Risk</td><td>NA</td></tr>
</table>

Notes:

NA – Management unit not assessed for endpoint; Ecological Receptors endpoints – Negligible Risk, Moderate Risk, High Risk; Human Health endpoints – Negligible Risk, Low Risk, Moderate Risk, High Risk

9.0 CLOSURE

We trust that the enclosed information is sufficient to meet your current needs. If you have any questions, or if we can be of further assistance, please do not hesitate to contact the undersigned at 604-296-4200.

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LEGEND

FEDERAL WATER LOT BOUNDARY

PARK

0 200 400

1:9,000 METERS

REFERENCE(S)
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2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
SPATIAL DOMAIN OF KIH STUDY AREA AND WATER LOT BOUNDARIES

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

PATH: Y:\burnaby\CAD-GIS\Client\PWGSC\Kingston_Inner_Harbour\99_PROJECTS\1416134\02_PRODUCTION\6000\MXD\Report\1416134_Figure_02_KIH_Management_Units.mxd

LEGEND

FEDERAL WATER LOT BOUNDARY

MANAGEMENT UNIT

0 200 400

1:9,000 METERS

REFERENCES

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CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
SPATIAL DOMAIN OF KIH STUDY AREA AND MANAGEMENT UNITS

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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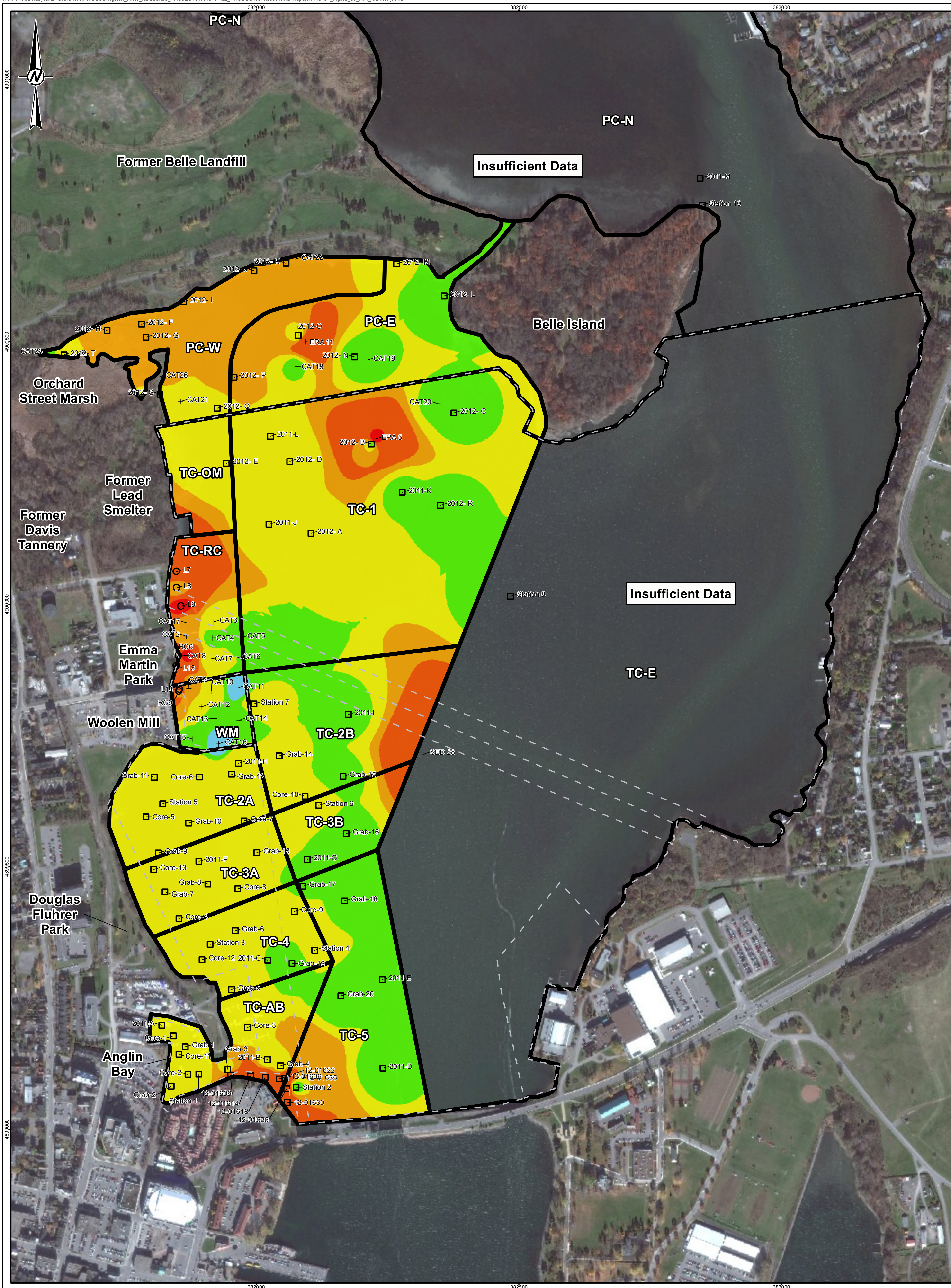

LEGEND

- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- 2003 - 2005 SEDIMENT SAMPLE
- 2006 - 2009 SEDIMENT SAMPLE
- 2010 - 2013 SEDIMENT SAMPLE

ANTIMONY

- 0 - 0.2 mg/kg
- 0.2 - 0.6 mg/kg (<LAET)
- 0.6 - 1.9 mg/kg (<2LAET)
- 1.9 - 6 mg/kg
- 6 - 20 mg/kg
- > 20 mg/kg

0 150 300

1:7,000 METERS

NOTE(S)

1. SAMPLES COLLECTED PRIOR TO THE 2005 REMEDIAL DREDGING NEAR THE KINGSTON ROWING CLUB ARE NOT INCLUDED.

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CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
ANTIMONY BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2003-2013)

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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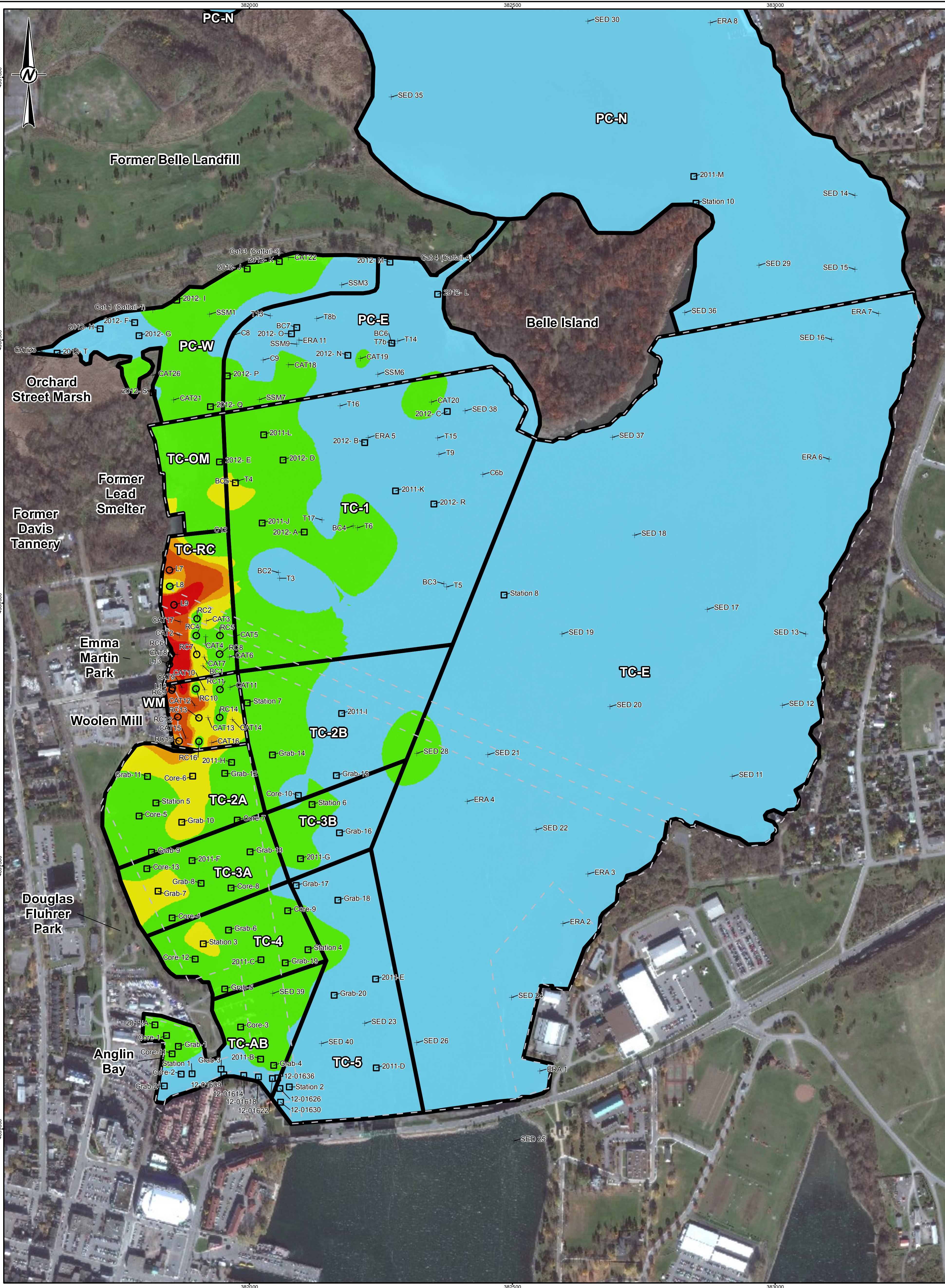

LEGEND

FEDERAL WATER LOT BOUNDARY

MANAGEMENT UNIT

2003 - 2005 SEDIMENT SAMPLE

2006 - 2009 SEDIMENT SAMPLE

2010 - 2013 SEDIMENT SAMPLE

ARSENIC

0 - 5.9 mg/kg (<ISQG)

5.9 - 17 mg/kg (<PEL)

17- 33 mg/kg (<SEL)

33 - 50.9 mg/kg (<2LAET)

50.9 - 100 mg/kg

> 100 mg/kg

0 150 300

1:7,000 METERS

NOTE(S)

1. SAMPLES COLLECTED PRIOR TO THE 2005 REMEDIAL DREDGING NEAR THE KINGSTON ROWING CLUB ARE NOT INCLUDED.

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CLIENT

PWGSC

PROJECT

KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE

ARSENIC BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2003-2013)

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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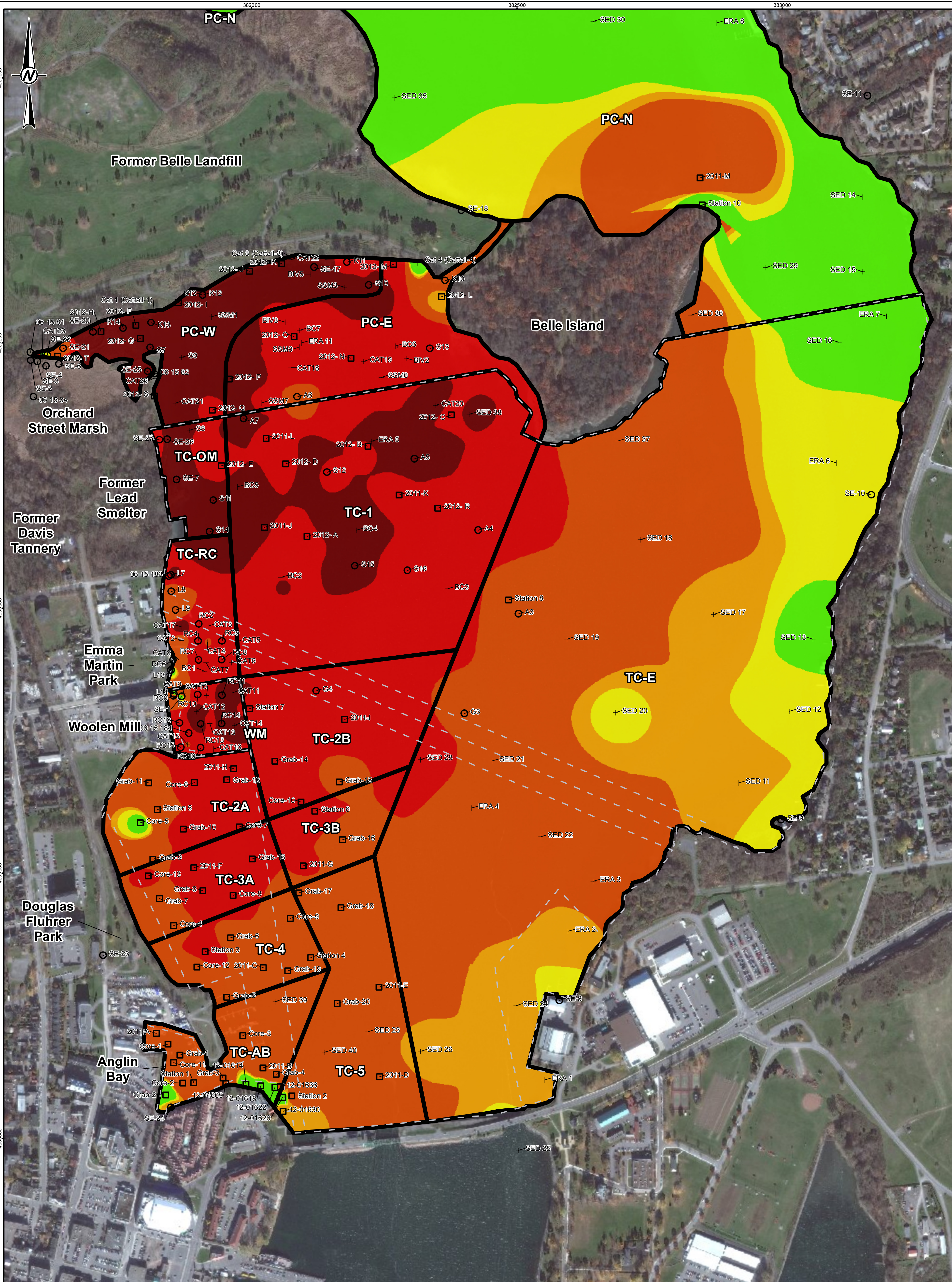

LEGEND

- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- 2001 - 2005 SEDIMENT SAMPLE
- 2006 - 2009 SEDIMENT SAMPLE
- 2010 - 2013 SEDIMENT SAMPLE

CHROMIUM

- 0 - 37.3 mg/kg (<ISQG)
- 37.3 - 90 mg/kg (<PEL)
- 90 - 110 mg/kg (<SEL)
- 110 - 133 mg/kg (<2LAET)
- 133 - 500 mg/kg
- 500 - 1,000 mg/kg
- > 1,000 mg/kg

0 150 300

1:7,000 METERS

NOTE(S)

1. SAMPLES COLLECTED PRIOR TO THE 2005 REMEDIAL DREDGING NEAR THE KINGSTON ROWING CLUB ARE NOT INCLUDED.

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2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
CHROMIUM BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2003-2013)

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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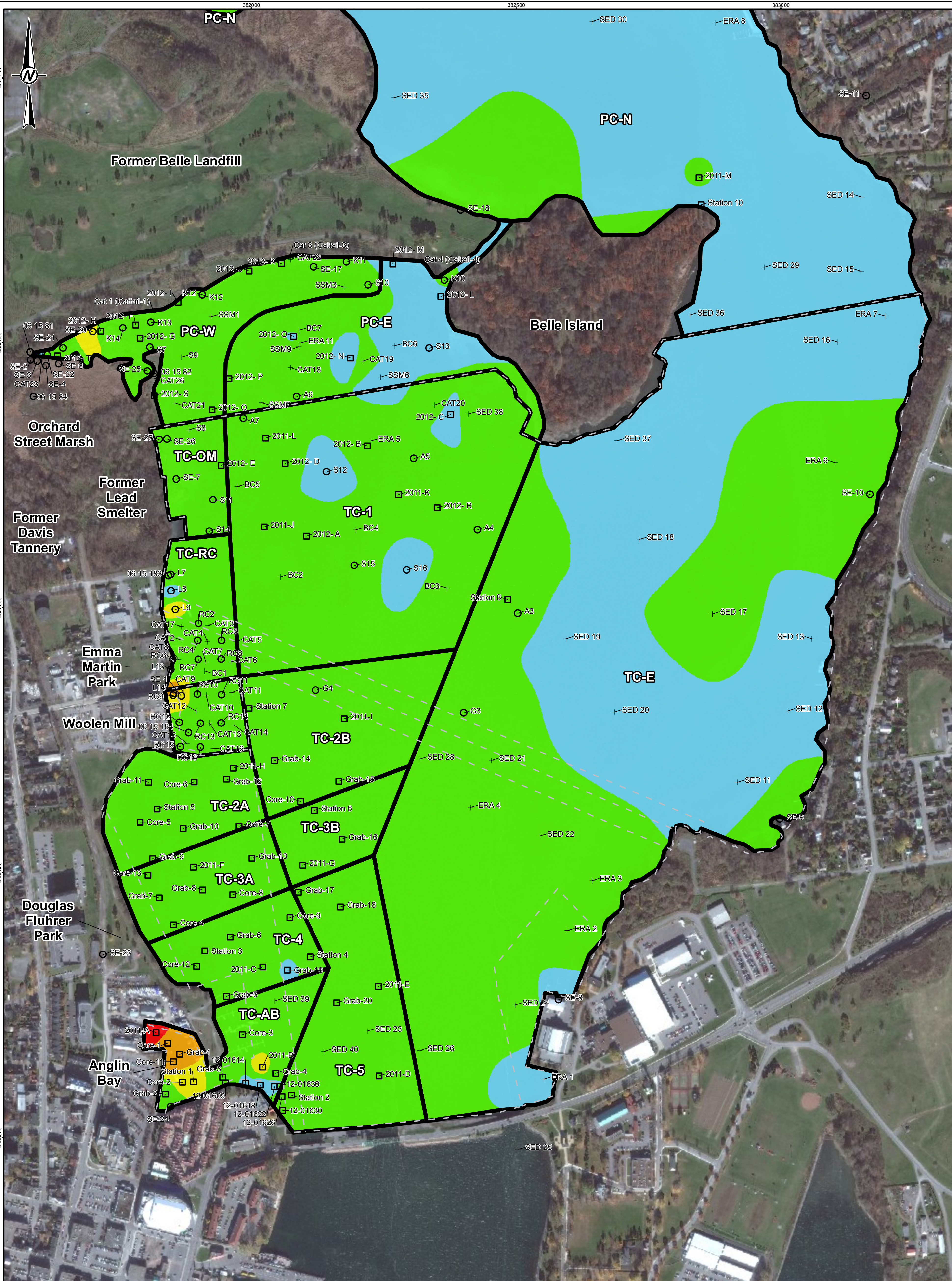

LEGEND

- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- 2001 - 2005 SEDIMENT SAMPLE
- 2006 - 2009 SEDIMENT SAMPLE
- 2010 - 2013 SEDIMENT SAMPLE

COPPER

- 0 - 35.7 mg/kg (<ISQG)
- 35.7 - 110 mg/kg (<SEL)
- 110 - 197 mg.kg (<PEL)
- 197 - 619 mg/kg (<LAET)
- 619 - 829 mg/kg (<2LAET)

0 150 300

1:7,000 METERS

NOTE(S)

1. SAMPLES COLLECTED PRIOR TO THE 2005 REMEDIAL DREDGING NEAR THE KINGSTON ROWING CLUB ARE NOT INCLUDED.

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CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
COPPER BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2003-2013)

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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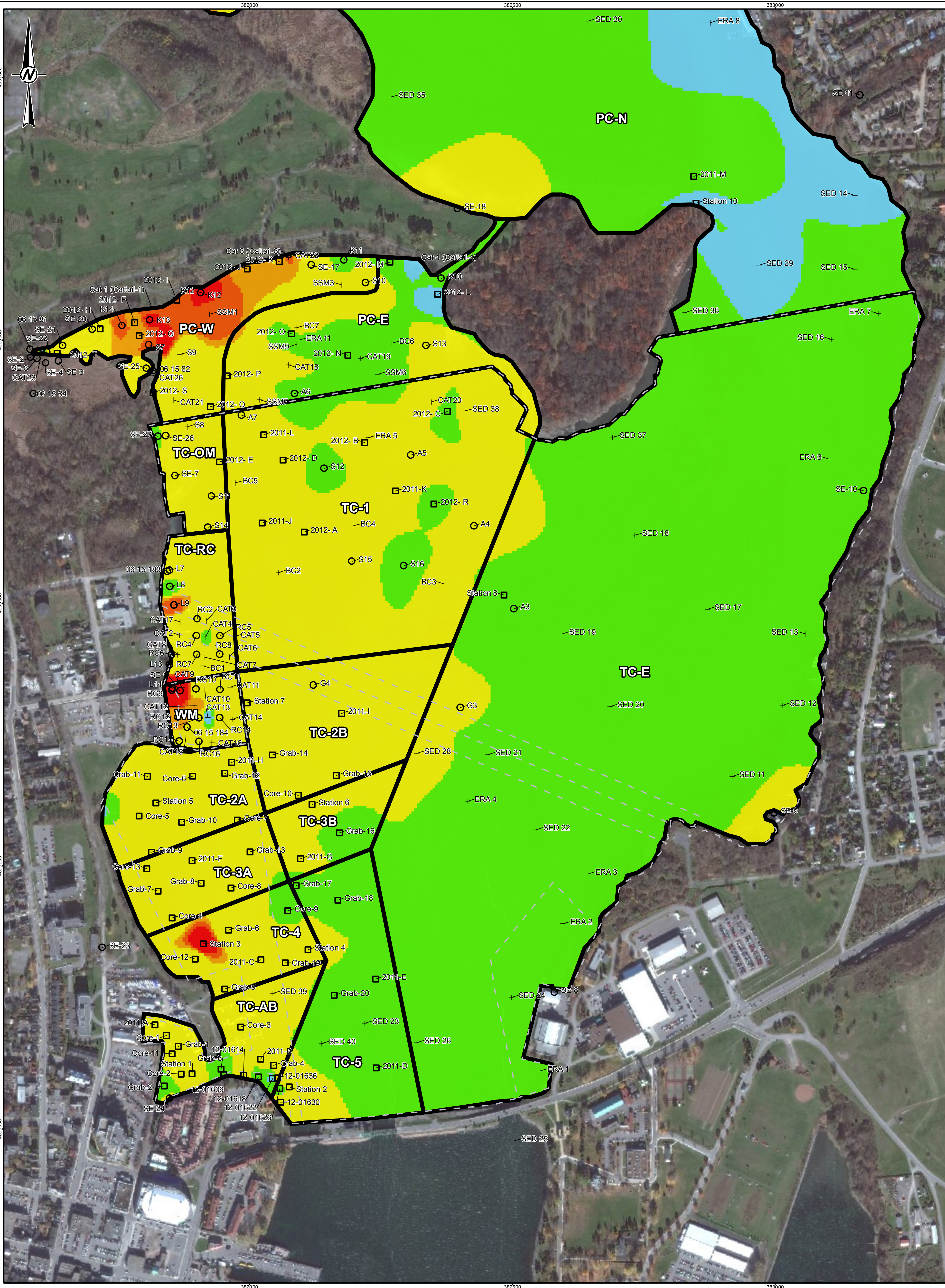

LEGEND

- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- 2001 - 2005 SEDIMENT SAMPLE
- 2006 - 2009 SEDIMENT SAMPLE
- 2010 - 2013 SEDIMENT SAMPLE

LEAD

- 0 - 35 mg/kg (<ISQG)
- 35 - 91.3 mg/kg (<PEL)
- 91.3 - 250 mg/kg
- 250 - 335 mg/kg (<LAET)
- 335 - 431 mg/kg (<2LAET)
- >431 mg/kg

0 150 300

1:7,000 METERS

NOTE(S)

1. SAMPLES COLLECTED PRIOR TO THE 2005 REMEDIAL DREDGING NEAR THE KINGSTON ROWING CLUB ARE NOT INCLUDED.

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2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
LEAD BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2003-2013)

CONSULTANT

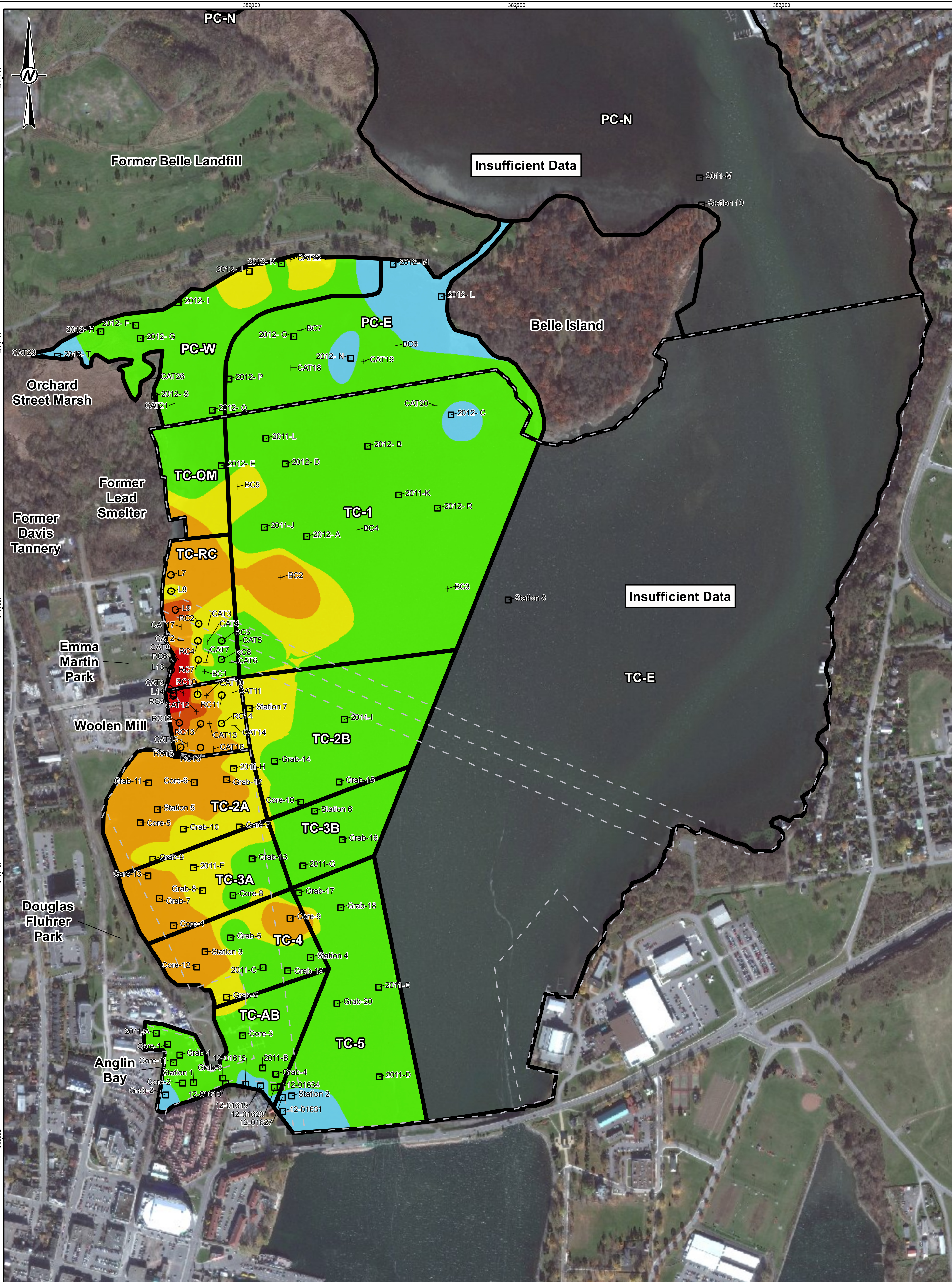
Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	7

25mm

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



LEGEND

- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- 2003 - 2005 SEDIMENT SAMPLE
- 2006 - 2009 SEDIMENT SAMPLE
- 2010 - 2013 SEDIMENT SAMPLE

MERCURY

- 0 - 0.17 mg/kg (<ISQG)
- 0.17 - 0.486 mg/kg (<PEL)
- 0.486 - 0.8 mg/kg (<LAET)
- 0.8 - 2 mg/kg (<SEL)
- 2 - 3.04 mg/kg (<2LAET)
- > 3.04 mg/kg

0 150 300

1:7,000 METERS

NOTE(S)

1. SAMPLES COLLECTED PRIOR TO THE 2005 REMEDIAL DREDGING NEAR THE KINGSTON ROWING CLUB ARE NOT INCLUDED.

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2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
MERCURY BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2003-2013)

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	8

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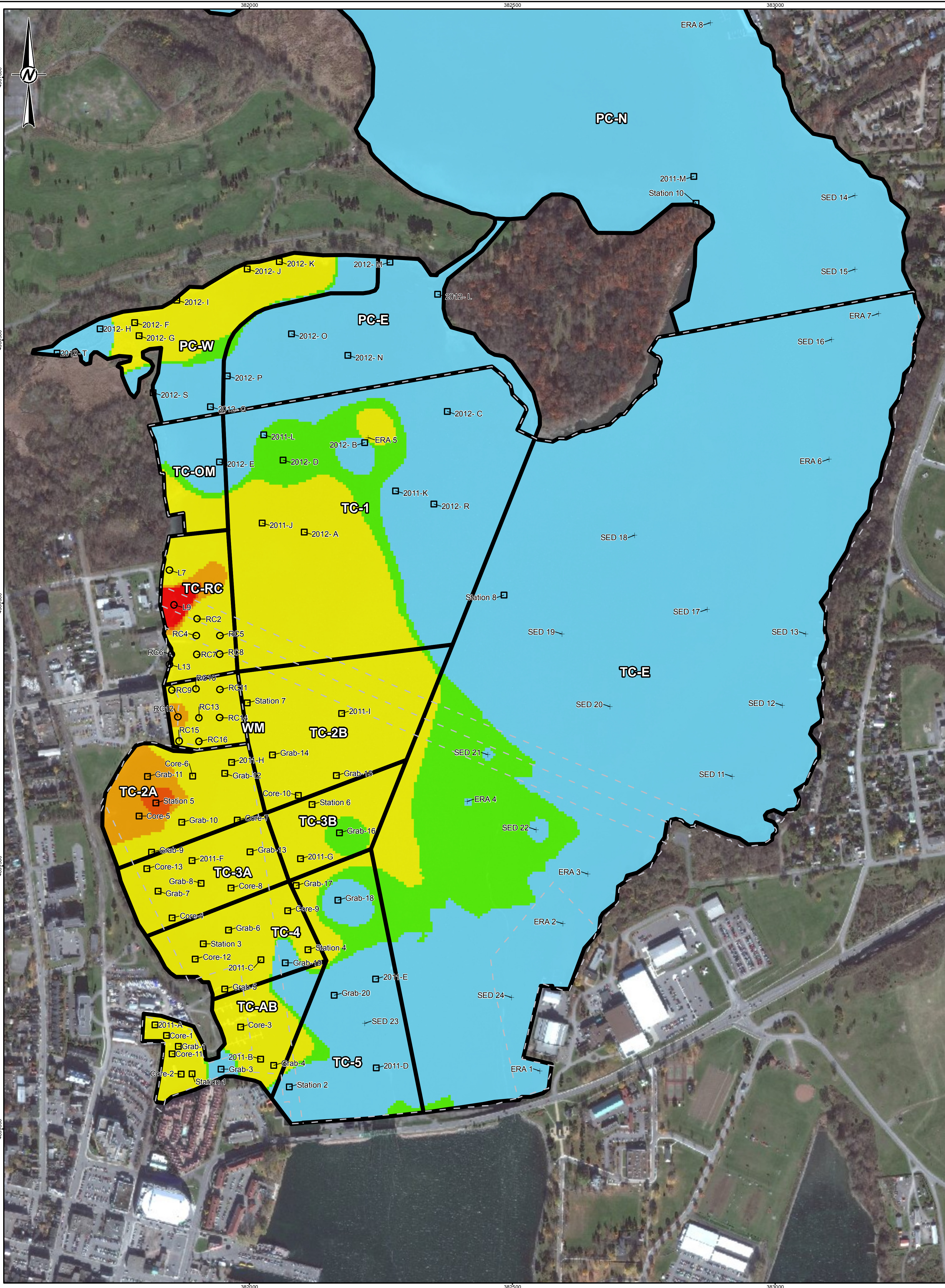

LEGEND

- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- 2001 - 2005 SEDIMENT SAMPLE
- 2006 - 2009 SEDIMENT SAMPLE
- 2010 - 2013 SEDIMENT SAMPLE

SILVER

- 0 - 0.5 mg/kg
- 0.5 - 0.545 mg/kg (<LAET)
- 0.545 - 2 mg/kg
- 2 - 3.5 mg/kg (<2LAET)
- 3.5 - 4.5 mg/kg
- > 4.5 mg/kg

0 150 300

1:7,000 METERS

NOTE(S)

1. SAMPLES COLLECTED PRIOR TO THE 2005 REMEDIAL DREDGING NEAR THE KINGSTON ROWING CLUB ARE NOT INCLUDED.

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2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
SILVER BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2003-2013)

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	9

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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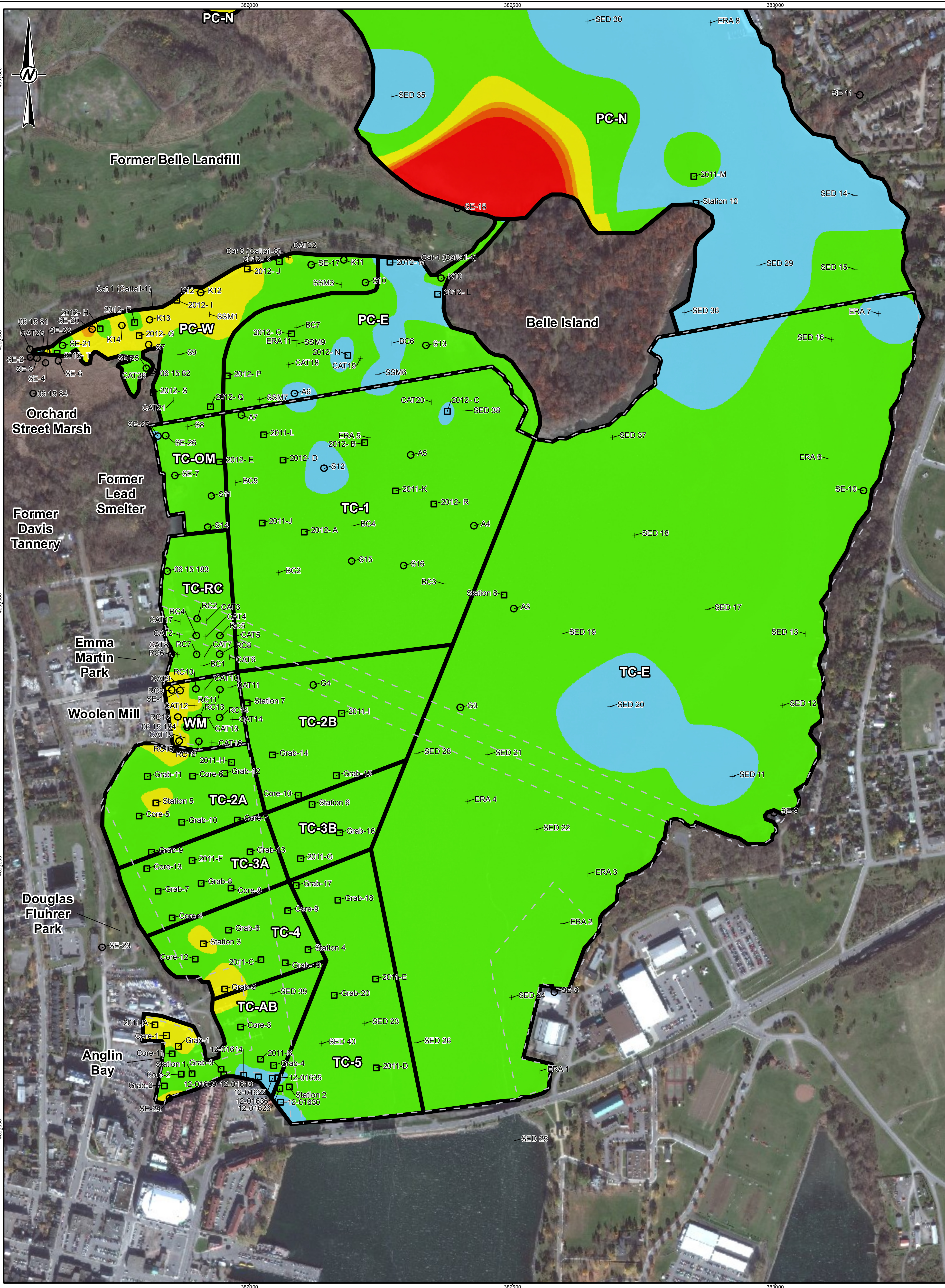

LEGEND

- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- 2001 - 2005 SEDIMENT SAMPLE
- 2006 - 2009 SEDIMENT SAMPLE
- 2010 - 2013 SEDIMENT SAMPLE

ZINC

- 0 - 123 mg/kg (<ISQG)
- 123 - 315 mg/kg (<PEL)
- 315 - 683 mg/kg (<LAET)
- 683 - 820 mg/kg (<SEL)
- 820 - 1080 mg/kg (<2LAET)
- > 1080 mg/kg

0 150 300

1:7,000 METERS

NOTE(S)

1. SAMPLES COLLECTED PRIOR TO THE 2005 REMEDIAL DREDGING NEAR THE KINGSTON ROWING CLUB ARE NOT INCLUDED.

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2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
ZINC BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2003-2013)

CONSULTANT

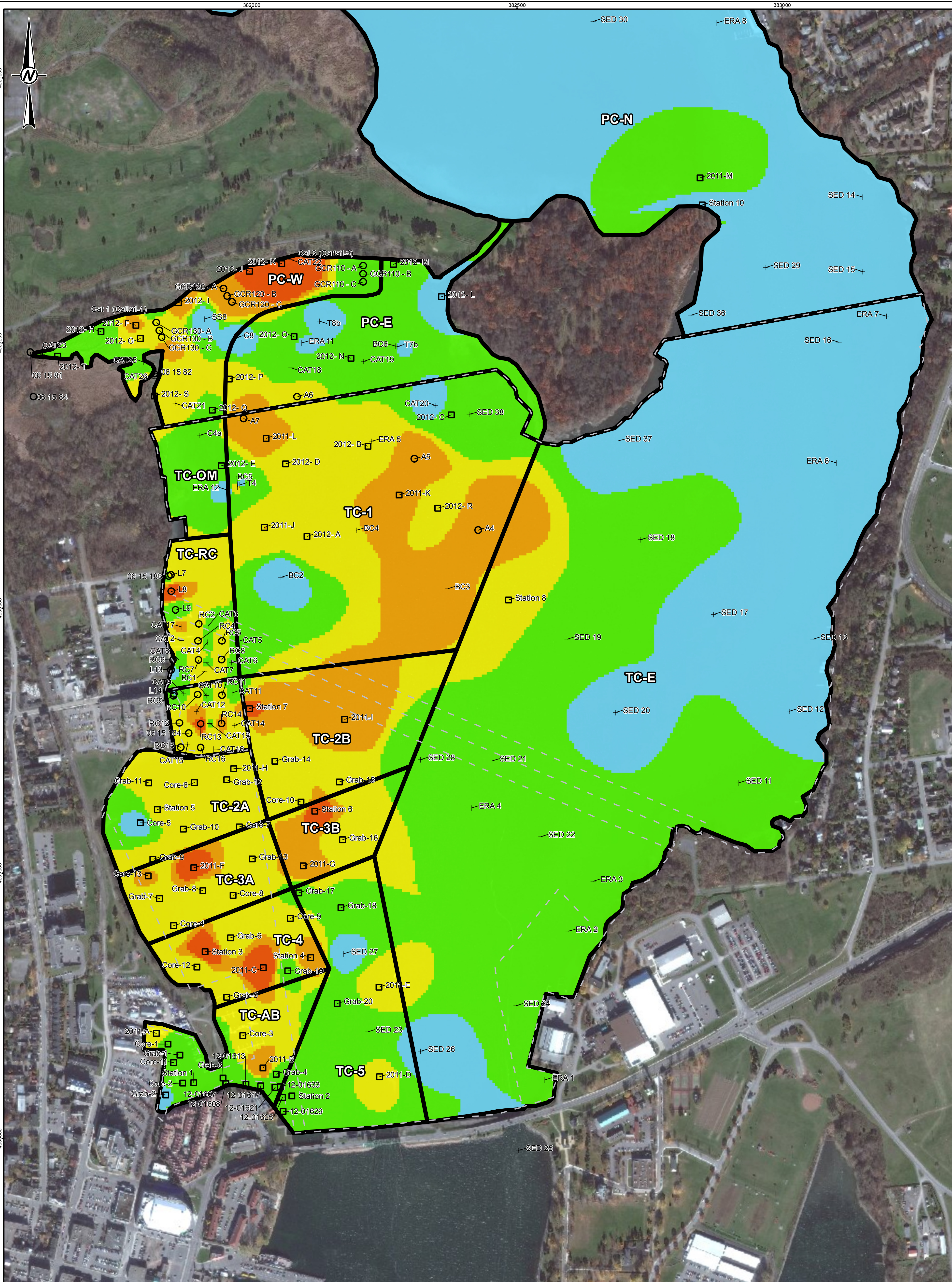
Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	10

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm



LEGEND

- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- 2003 - 2005 SEDIMENT SAMPLE
- 2006 - 2009 SEDIMENT SAMPLE
- 2010 - 2013 SEDIMENT SAMPLE

TOTAL PCB

- 0 - 0.07 mg/kg (<LEL)
- 0.07 - 0.3 mg/kg (<PEL)
- 0.3 - 0.6 mg/kg (<LAET)
- 0.6 - 1 mg/kg
- 1 - 5.3 mg/kg (<SEL)
- > 5.3 mg/kg (>SEL)

0 150 300

1:7,000 METERS

NOTE(S)

1. SAMPLES COLLECTED PRIOR TO THE 2005 REMEDIAL DREDGING NEAR THE KINGSTON ROWING CLUB ARE NOT INCLUDED.

REFERENCE(S)

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2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
TOTAL PCB BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2003-2013)

CONSULTANT

Golder Associates

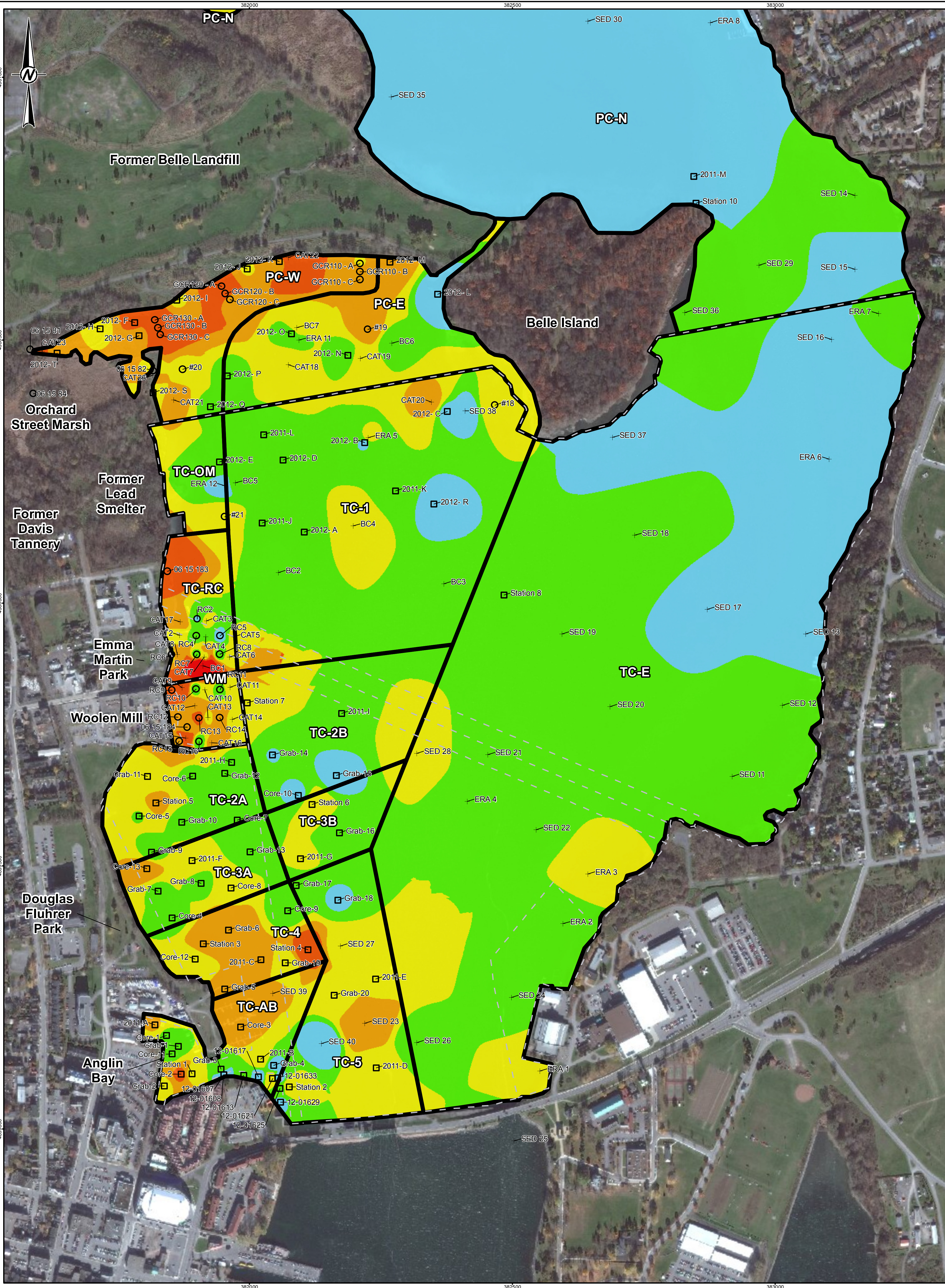
YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	11

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

PATH: Y:\burnaby\CAD-GIS\Client\PWGSC\Kingston_Inner_Harbour\99_PROJECTS\1416134\02_PRODUCTION\6000\MXD\Report\1416134_Figure_12_KIH_Total_PAH.mxd



LEGEND

FEDERAL WATER LOT BOUNDARY

MANAGEMENT UNIT

2003 - 2005 SEDIMENT SAMPLE

2006 - 2009 SEDIMENT SAMPLE

2010 - 2013 SEDIMENT SAMPLE

TOTAL PAH

0 - 1.61 mg/kg (<TEC)

1.61 - 4 mg/kg (<LEL)

4 - 10 mg/kg

10 - 22.8 mg/kg (<PEC)

22.8 - 100 mg/kg

100 - 750 mg/kg (<SEL)

0 150 300

1:7,000 METERS

NOTE(S)

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CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
TOTAL PAH BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2003-2013)

CONSULTANT

Golder Associates

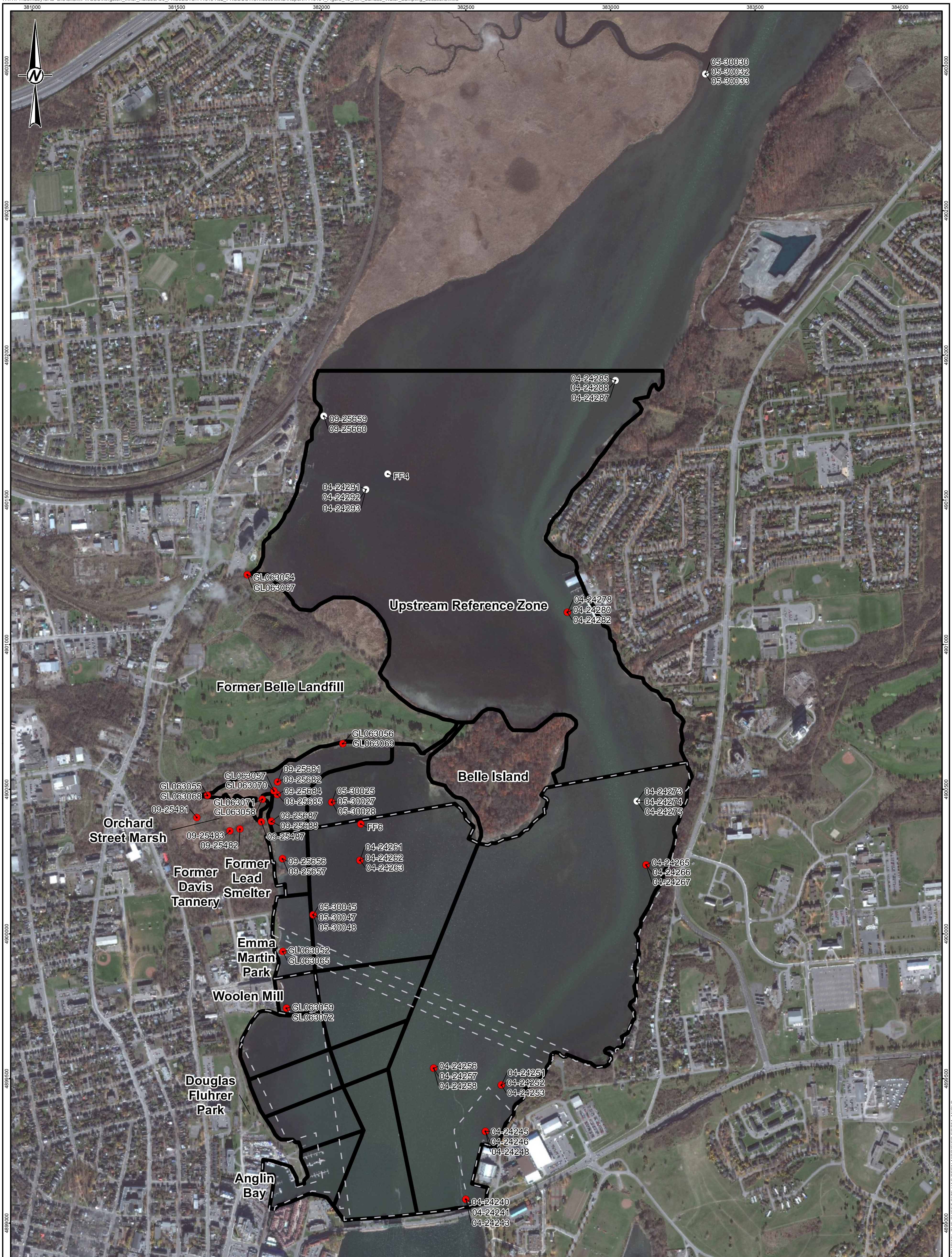
YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	12

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

PATH: Y:\burnaby\CAD-GIS\Client\PWGSC\Kingston_Inner_Harbour\99_PROJECTS\1416134\02_PRODUCTION\6000\MXD\Report\1416134_Figure_13_KIH_Surface_Water_Sampling_Locations.mxd



LEGEND

- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- REFERENCE STATION
- APEC STATION

0 250 500

1:12,500 METERS

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2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
KIH SURFACE WATER SAMPLING LOCATIONS

CONSULTANT

Golder Associates

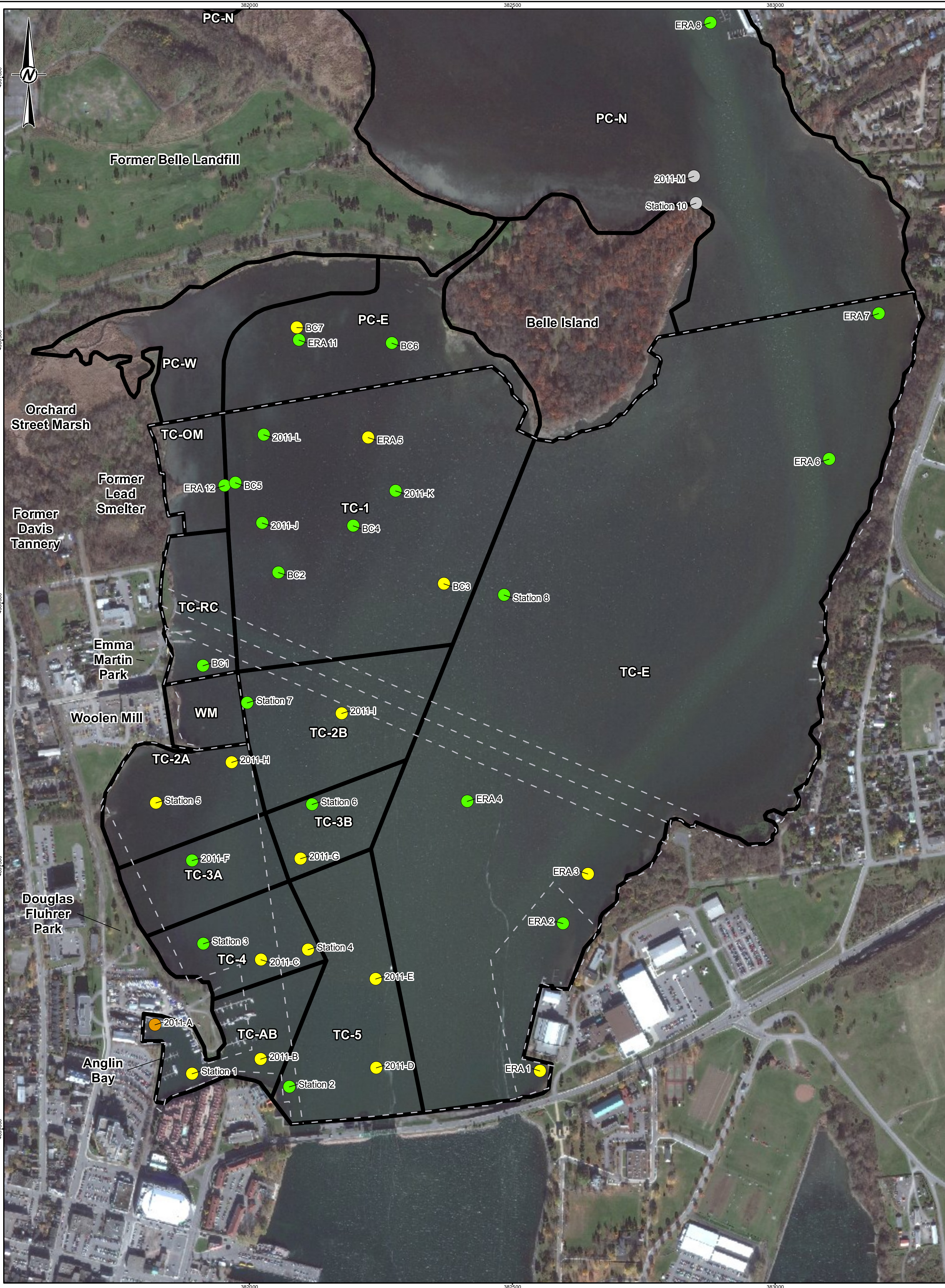
YYYY-MM-DD	2016-08-12
DESIGNED	VH
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	13

25mm

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

PATH: Y:\burnaby\CAD-GIS\Client\PWGSC\Kingston_Inner_Harbour\99_PROJECTS\1416134\02_PRODUCTION\6000\MXD\Report\1416134_Figure_14_Overall_Benthic_Community.mxd



LEGEND

FEDERAL WATER LOT BOUNDARY

MANAGEMENT UNIT

BENTHIC COMMUNITY

SIGNIFICANT: A MAJORITY OF SAMPLES SHOW MAJOR DIFFERENCES IN BENTHIC INDICES

POTENTIAL: MULTIPLE SLIGHT DIFFERENCES IN MORE THAN ONE INDICES AND/OR ONE MAJOR DIFFERENCE

NEGLIGIBLE: EQUIVALENT TO REFERENCE STATION OR SLIGHT DIFFERENCE IN NO MORE THAN ONE INDICES

REFERENCE

0 150 300

1:7,000 METERS

NOTE(S)

1. SAMPLES COLLECTED PRIOR TO THE 2005 REMEDIAL DREDGING NEAR THE KINGSTON ROWING CLUB ARE NOT INCLUDED.

REFERENCE(S)

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2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
SITE SPECIFIC ORDINAL RANKINGS FOR WOE CATEGORIZATIONS FOR THE BENTHIC COMMUNITY

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	14

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

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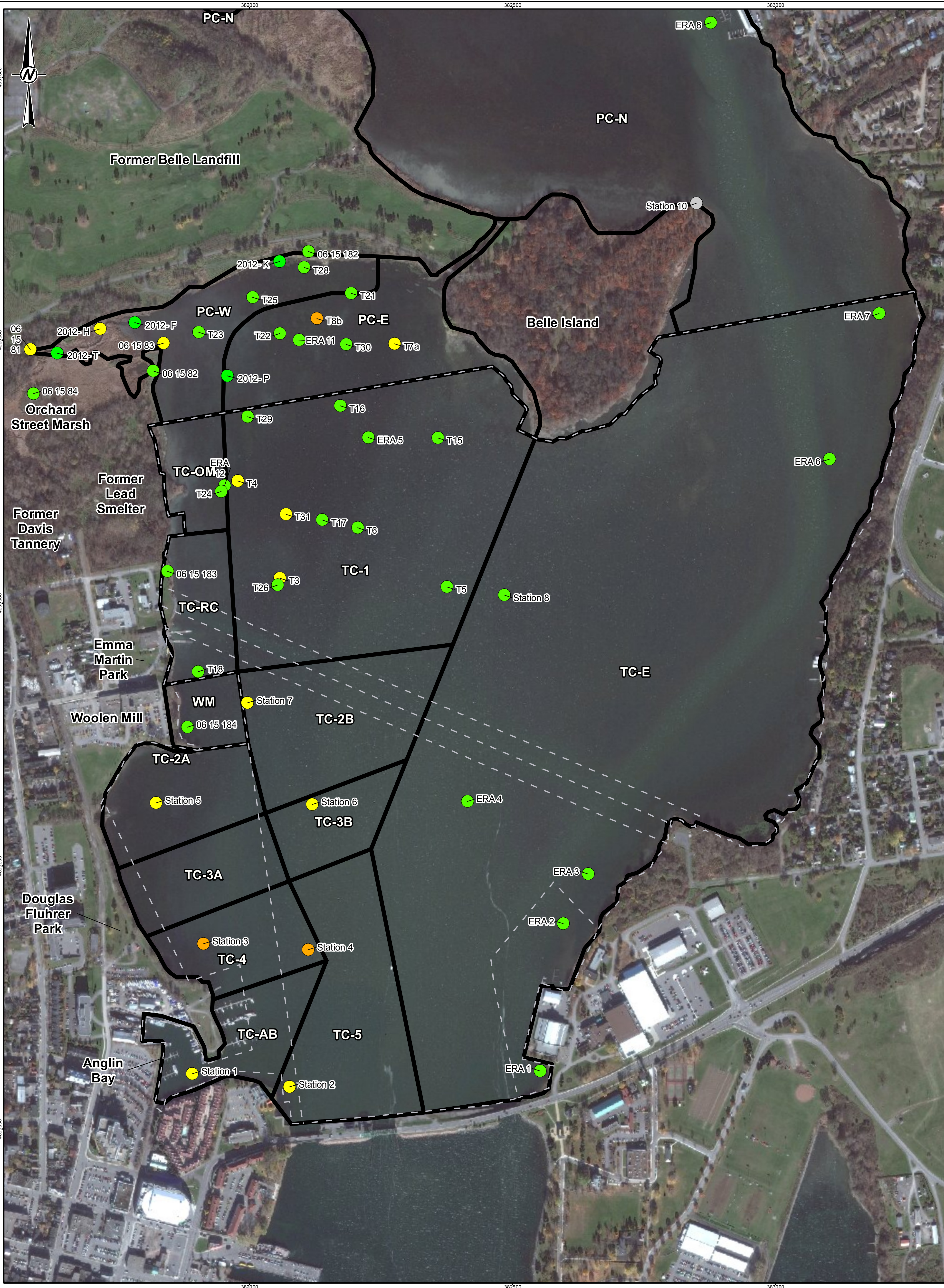

LEGEND

FEDERAL WATER LOT BOUNDARY

MANAGEMENT UNIT

OVERALL TOXICITY

SIGNIFICANT: MULTIPLE TESTS/ENDPOINTS EXHIBIT MAJOR TOXICOLOGICAL EFFECTS

POTENTIAL: MULTIPLE TESTS/ENDPOINTS EXHIBIT MINOR TOXICOLOGICAL EFFECTS AND/OR ONE TEST/ENDPOINT EXHIBITS MAJOR EFFECTS

NEGLIGIBLE: MINOR TOXICOLOGICAL EFFECTS OBSERVED IN NO MORE THAN ONE ENDPOINT

REFERENCE

0 150 300

1:7,000 METERS

NOTE(S)

1. SAMPLES COLLECTED PRIOR TO THE 2005 REMEDIAL DREDGING NEAR THE KINGSTON ROWING CLUB ARE NOT INCLUDED.

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2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
SITE SPECIFIC ORDINAL RANKINGS FOR WOE CATEGORIZATIONS FOR TOXICITY

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

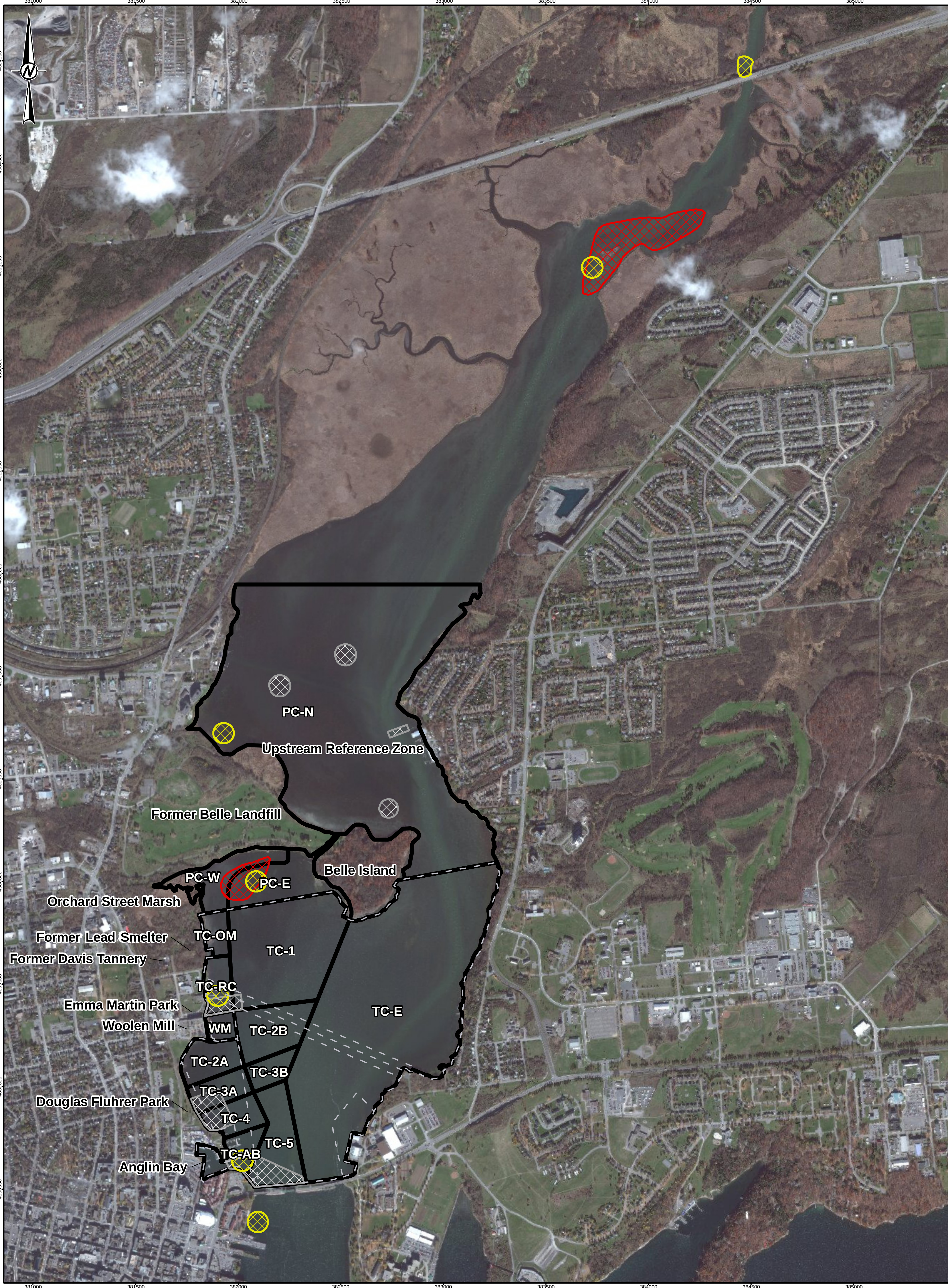
PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	15

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

PATH: Y:\burnaby\CAD-GIS\Client\PWGSC\Kingston_Inner_Harbour\99_PROJECTS\1416134\02_PRODUCTION\6000\MXD\Report\1416134_Figure_16_Sports_Fish_Collection_Areas.mxd



LEGEND

- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- GOLDER FISH COLLECTION (GOLDER 2011)
- JUVENILE YELLOW PERCH COLLECTION (SCHEIDER 2009)
- SPORT FISH COLLECTION AREA (RMC-ESG 2009)

0 400 800

1:18,000 METERS

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CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
KINGSTON INNER HARBOUR - SPORTS FISH AND JUVENILE YELLOW PERCH COLLECTION AREAS

CONSULTANT

Golder Associates

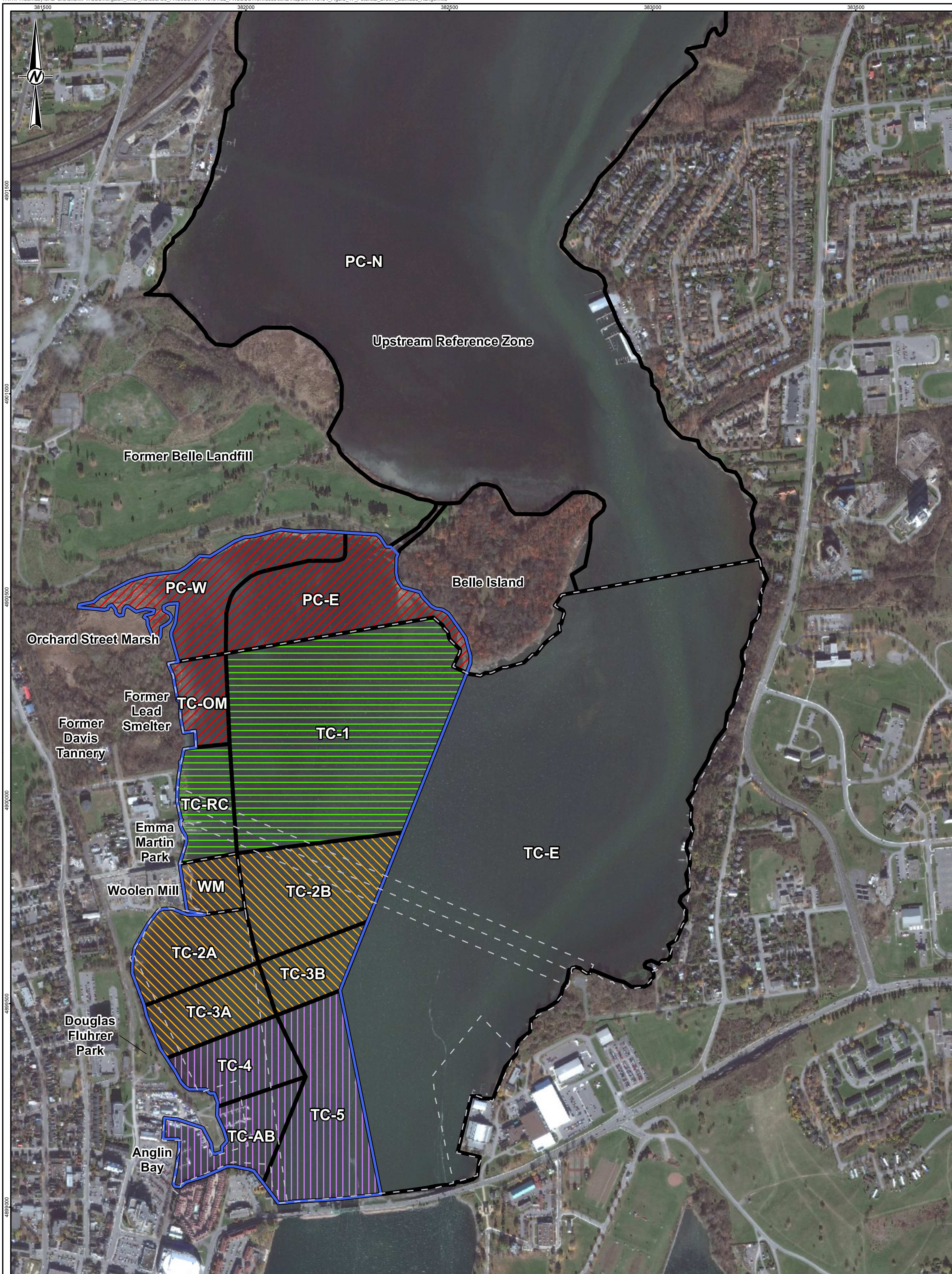
YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	16

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

PATH: Y:\burnaby\CAD-GIS\Client\PWGSC\Kingston_Inner_Harbour\99_PROJECTS\1416134\02_PRODUCTION\6000\MXD\Report\1416134_Figure_17_Potential_Brown_Bullhead_Range.mxd



LEGEND

- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- EXPOSURE ZONE OF RELEVANCE FOR EFFECTS
- NORTH HABITAT
- NORTH-CENTRAL HABITAT
- SOUTH HABITAT
- SOUTH-CENTRAL HABITAT

0 200 400

1:9,000 METERS

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2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
POTENTIAL BROWN BULLHEAD HOME RANGES USED FOR THE ASSESSMENT OF FISH HEALTH

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	**17**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

PATH: Y:\burnaby\CAD-GIS\Client\PWGSC\Kingston_Inner_Harbour\99_PROJECTS\1416134\02_PRODUCTION\6000\MXD\Report\1416134_Figure_18_KIH_North_Medium_Study_Areas.mxd

LEGEND

- PHOTO LOCATION
- PHOTO DIRECTION AND LOCATION
- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- EXPOSURE ZONE OF RELEVANCE TO FISH CONSUMPTION PATHWAY
- SURFACE WATER EXPOSURE ZONE OF RELEVANCE
- SEDIMENT EXPOSURE ZONE OF RELEVANCE

0 200 400

1:9,000 METERS

NOTE

1. PHOTOS 1-4 WERE TAKEN IN THE NORTH PORTION OF THE STUDY AREA.

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CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
SPATIAL DOMAIN AND MANAGEMENT UNITS CONSIDERED IN THE RISK REFINEMENT FOR THE NORTH EXPOSURE AREA OF WESTERN KIH

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	VH
PREPARED	GI
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	**18**

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

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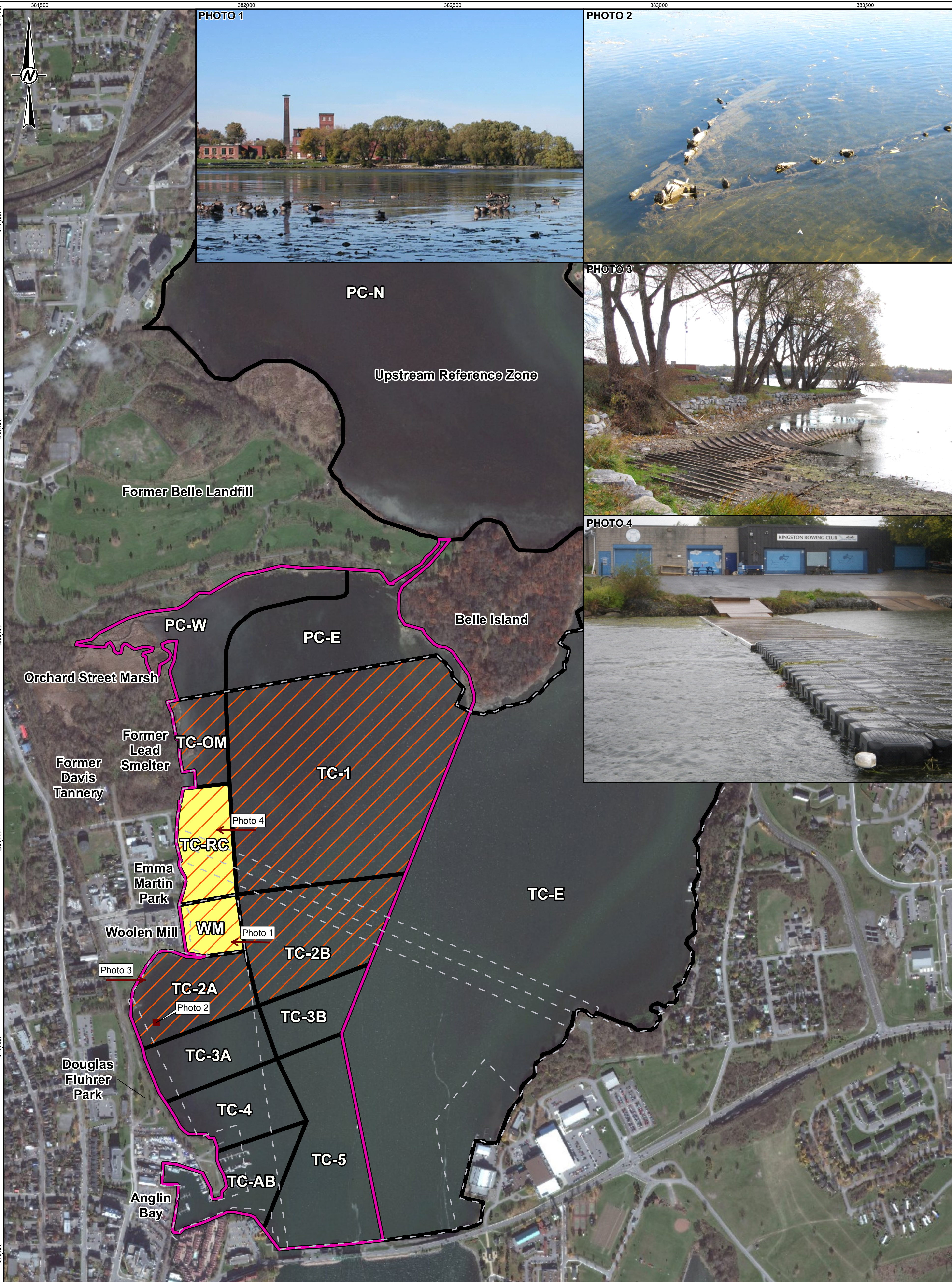

LEGEND

- PHOTO LOCATION
- PHOTO DIRECTION AND LOCATION
- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- EXPOSURE ZONE OF RELEVANCE TO FISH CONSUMPTION PATHWAY
- SURFACE WATER EXPOSURE ZONE OF RELEVANCE
- SEDIMENT EXPOSURE ZONE OF RELEVANCE

0 200 400

1:9,000 METERS

NOTE

1. PHOTOS 1-4 WERE TAKEN IN THE CENTRAL PORTION OF THE STUDY AREA.

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2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
SPATIAL DOMAIN AND MANAGEMENT UNITS CONSIDERED IN THE RISK REFINEMENT FOR THE CENTRAL EXPOSURE AREA OF WESTERN KIH

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	VH
PREPARED	GI
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	19

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

PATH: Y:\burnaby\CAD-GIS\Client\PWGSC\Kingston_Inner_Harbour\99_PROJECTS\1416134\02_PRODUCTION\6000\MXD\Report\1416134_Figure_20_KIH_South_Medium_Study_Areas.mxd

LEGEND

- PHOTO LOCATION
- PHOTO DIRECTION AND LOCATION
- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- EXPOSURE ZONE OF RELEVANCE TO FISH CONSUMPTION PATHWAY
- SURFACE WATER EXPOSURE ZONE OF RELEVANCE
- SEDIMENT EXPOSURE ZONE OF RELEVANCE

0 200 400

1:9,000 METERS

NOTE
1. PHOTOS 1-5 WERE TAKEN IN THE SOUTH PORTION OF THE STUDY AREA.

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2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
SPATIAL DOMAIN AND MANAGEMENT UNITS CONSIDERED IN THE RISK REFINEMENT FOR THE SOUTH EXPOSURE AREA OF WESTERN KIH

CONSULTANT
Golder Associates

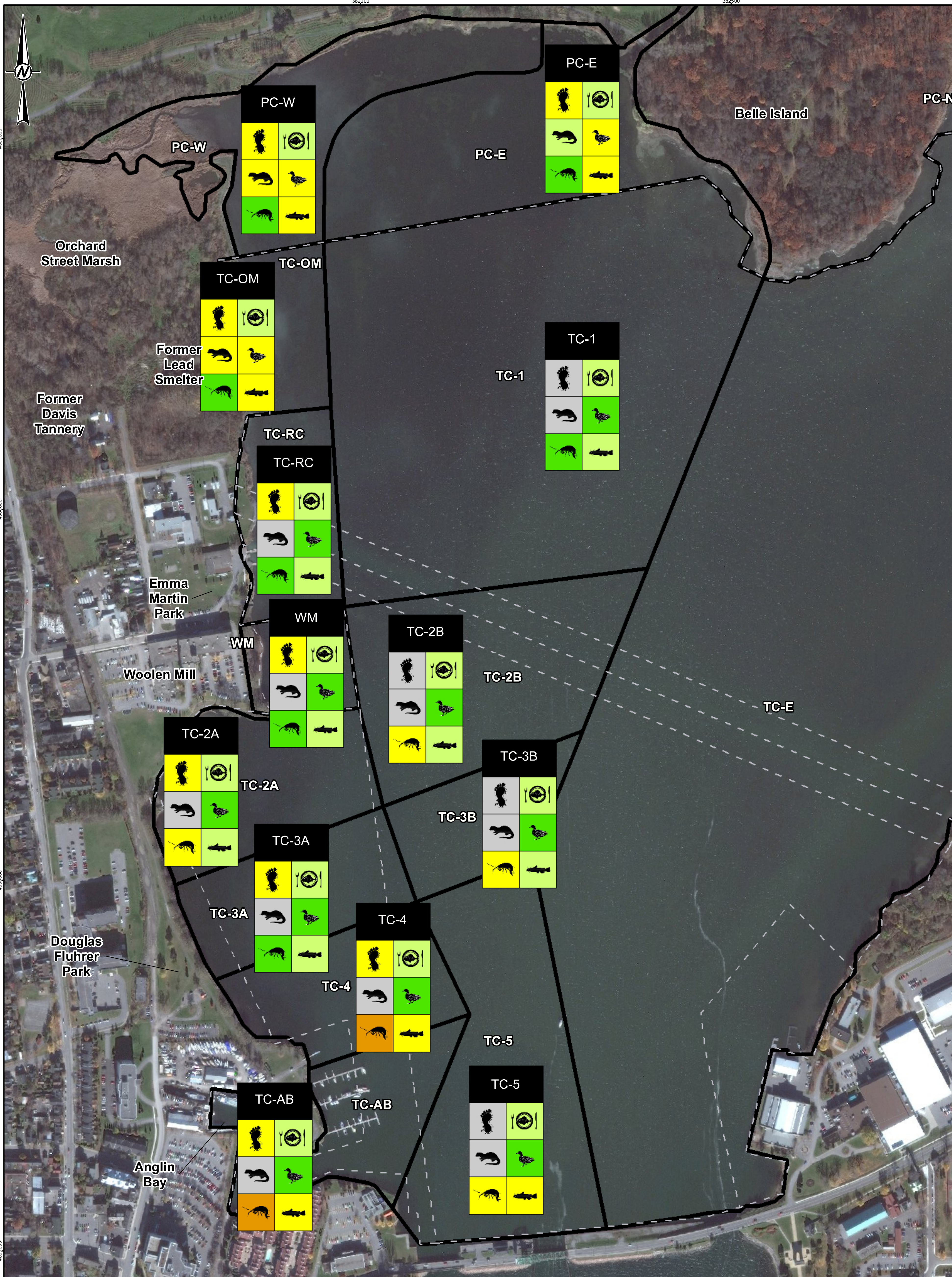
YYYY-MM-DD	2016-08-12
DESIGNED	VH
PREPARED	GI
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	20

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

PATH: Y:\burnaby\CAD-GIS\Client\PWGSC\Kingston_Inner_Harbour\99_PROJECTS\1416134\02_PRODUCTION\6000\MXD\Report\1416134_Figure_21_Management_Unit_Risk.mxd



LEGEND

FEDERAL WATER LOT BOUNDARY

MANAGEMENT UNIT

RISK

NOT APPLICABLE

NEGLIGIBLE RISK

LOW RISK

MODERATE RISK

HIGH RISK

Legend

HUMANS (SEDIMENT CONTACT) | HUMANS (FISH INGESTION)

AQUATIC MAMMALS | INSECTIVOROUS BIRDS

BENTHIC INVERTEBRATES | BOTTOM FISH

0 100 200

1:5,000 METERS

NOTE(S)

1. SAMPLES COLLECTED PRIOR TO THE 2005 REMEDIAL DREDGING NEAR THE KINGSTON ROWING CLUB ARE NOT INCLUDED.
2. NA – MANAGEMENT UNIT NOT ASSESSED FOR ENDPOINT.
3. EFFECTS TO BENTHIC COMMUNITIES – NEGLIGIBLE RISK, MODERATE RISK, HIGH RISK.

REFERENCE(S)

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2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
SUMMARY OF RISKS TO HUMAN HEALTH, AND AQUATIC AND WILDLIFE RECEPTORS

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-12
DESIGNED	SS
PREPARED	JP
REVIEWED	GL
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1416134	6000	0	21

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

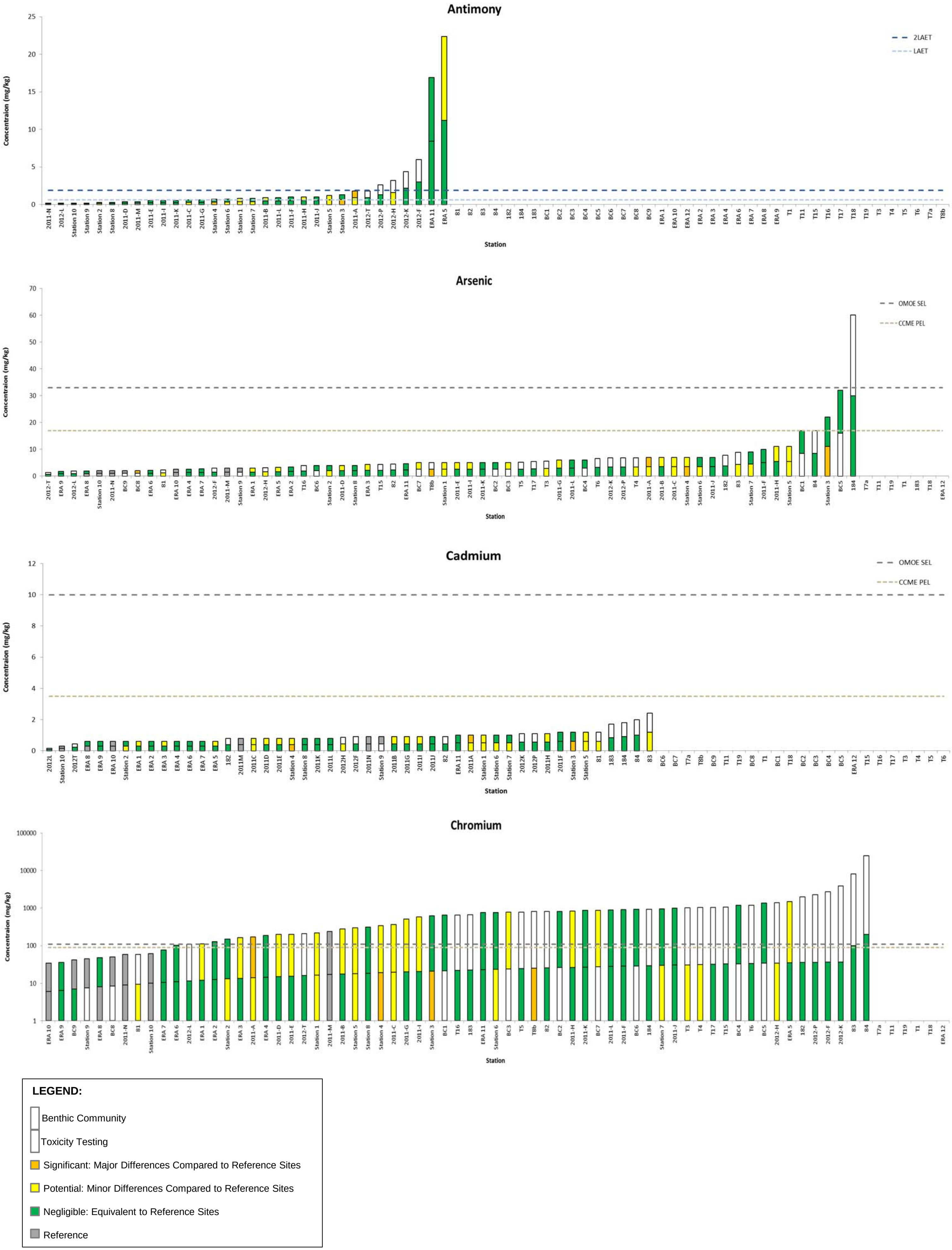
25mm

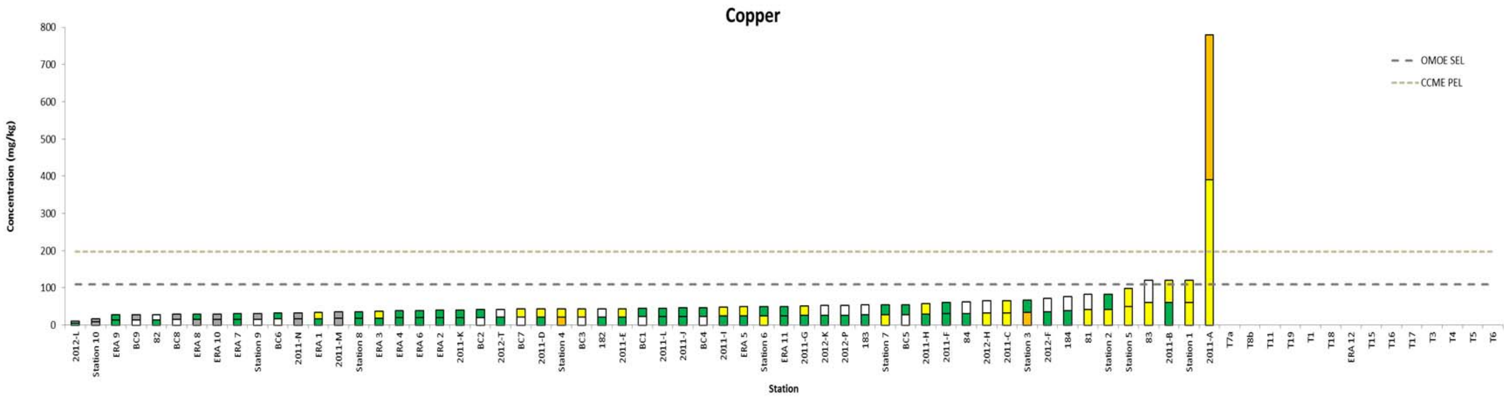
0

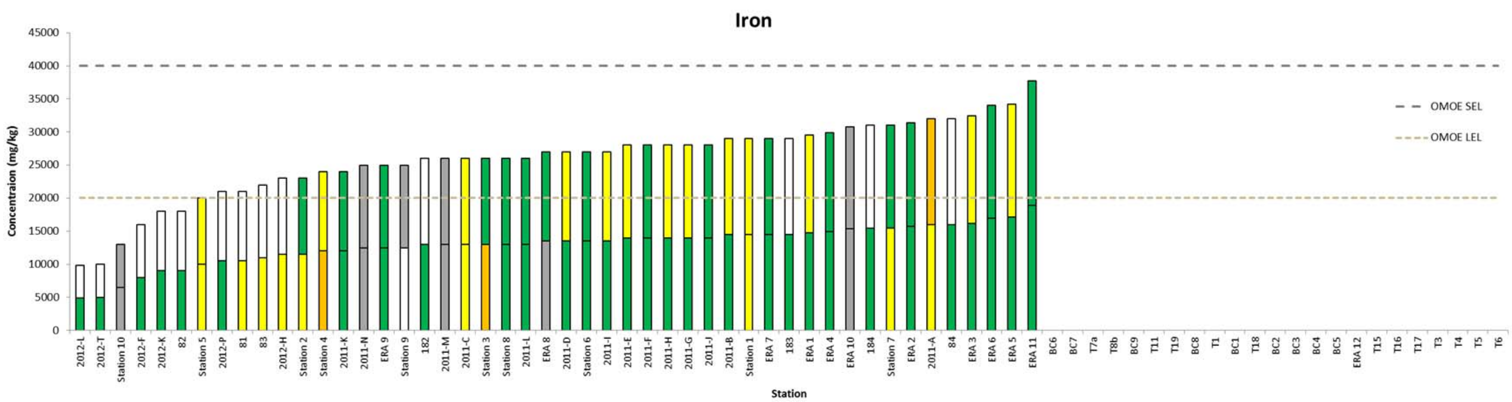
APPENDIX A

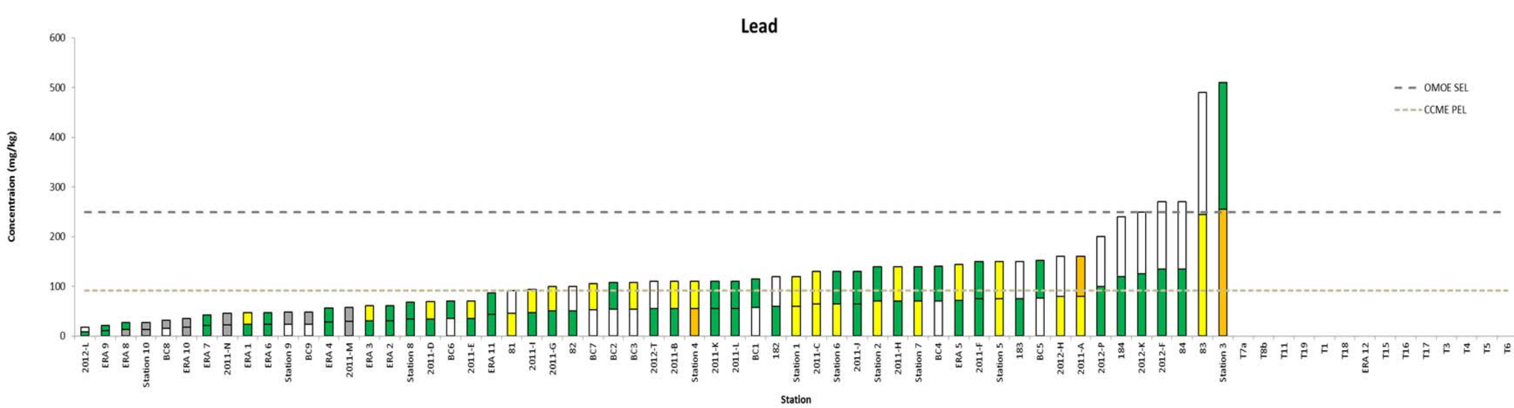
Rank Order COPC Concentration versus Benthic and Toxicological Impairment

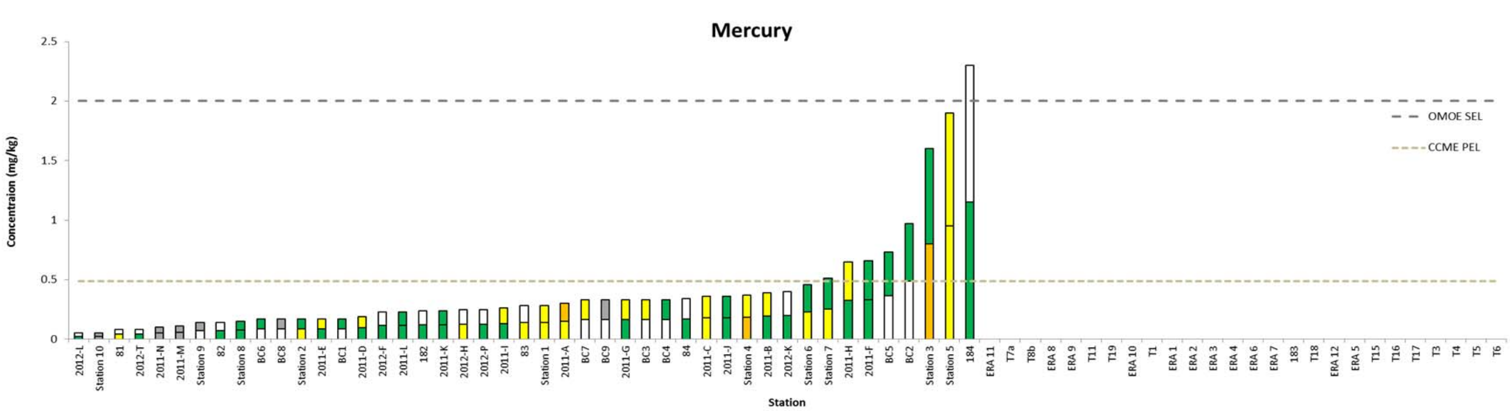
Figure 1: Rank order COPC concentration versus benthic (top) and toxicological (bottom) impairment relative to reference conditions for KIH sites.

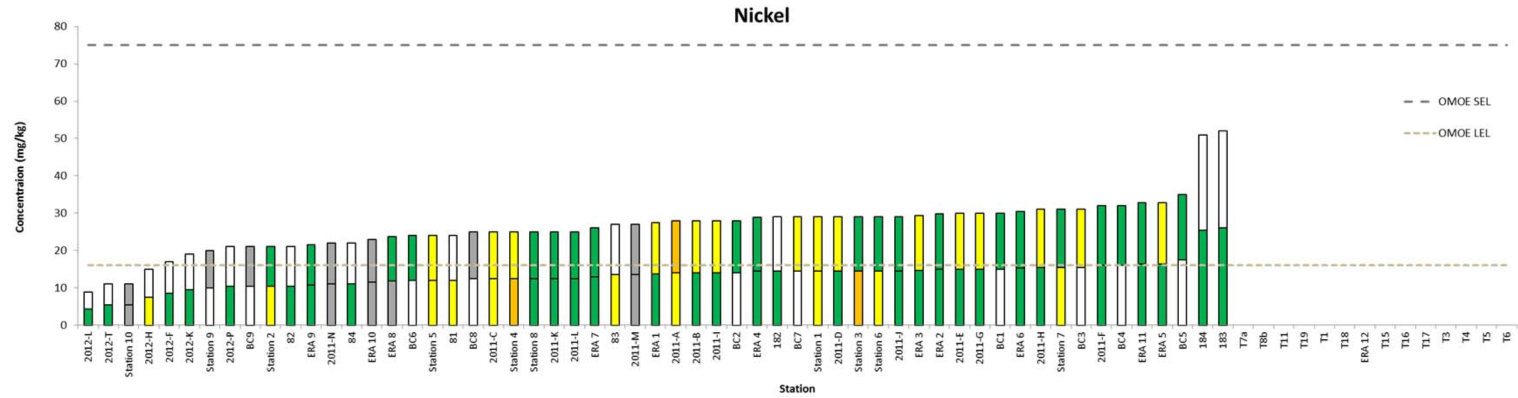


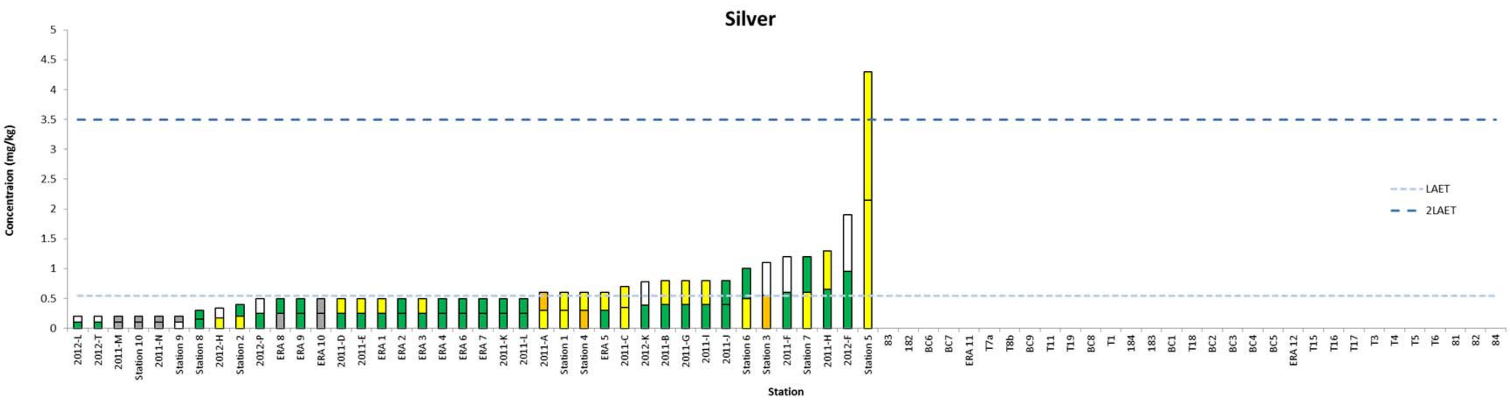

Copper
Concentraion (mg/kg)
0 100 200 300 400 500 600 700 800
OMOE SEL
CCME PEL
2012-L Station 10 ERA 9 BC9 82 BC8 ERA 8 ERA 10 ERA 7 Station 9 BC6 2011-N ERA 1 2011-M Station 8 ERA 3 ERA 4 ERA 6 ERA 2 2011-K BC2 2012-T BC7 2011-D Station 4 BC3 182 2011-E BC1 2011-L 2011-J BC4 2011-I ERA 5 Station 6 ERA 11 2011-G 2012-K 2012-P 183 Station 7 BC5 2011-H 2011-F 84 2012-H 2011-C Station 3 2012-F 184 81 Station 2 Station 5 83 2011-B Station 1 2011-A T7a T8b T11 T19 T1 T18 ERA 12 T15 T16 T17 T3 T4 T5 T6
Station

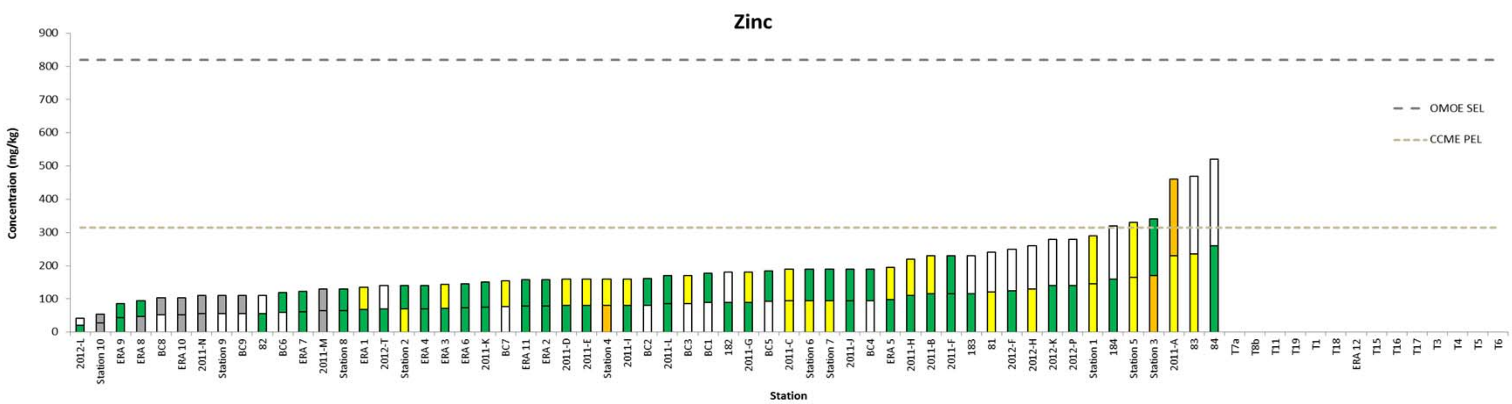

Iron
Concentraion (mg/kg)
0 5000 10000 15000 20000 25000 30000 35000 40000 45000
OMOE SEL
OMOE LEL
2012-L 2012-T Station 10 2012-F 2012-K 82 Station 5 2012-P 81 83 2012-H Station 2 Station 4 2011-K 2011-N ERA 9 Station 9 182 2011-M 2011-C Station 3 Station 8 2011-L ERA 8 2011-D Station 6 2011-I 2011-E 2011-F 2011-H 2011-G 2011-J 2011-B Station 1 ERA 7 183 ERA 1 ERA 4 ERA 10 184 Station 7 ERA 2 2011-A 84 ERA 3 ERA 6 ERA 5 ERA 11 BC6 BC7 T7a T8b BC9 T11 T19 BC8 T1 BC1 T18 BC2 BC3 BC4 BC5 ERA 12 T15 T16 T17 T3 T4 T5 T6
Station

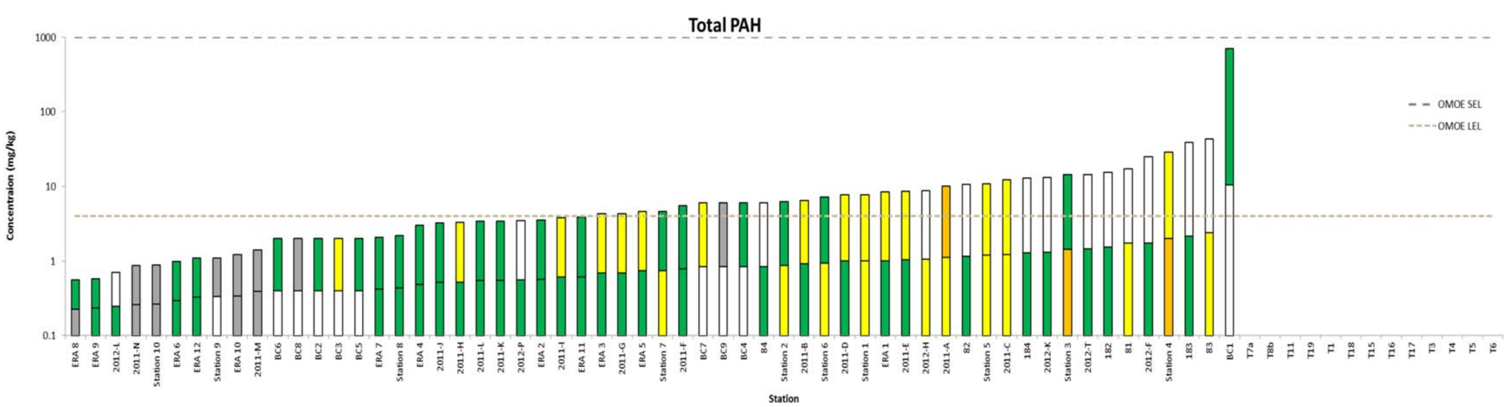

Lead
Concentraion (mg/kg)
0 100 200 300 400 500 600
OMOE SEL
CCME PEL
2012-L ERA 9 ERA 8 Station 10 BC8 ERA 10 ERA 7 2011-N ERA 1 ERA 6 Station 9 BC9 ERA 4 2011-M ERA 3 ERA 2 Station 8 2011-D BC6 2011-E ERA 11 81 2011-I 2011-G 82 BC7 BC2 BC3 2012-T 2011-B Station 4 2011-K 2011-L BC1 182 Station 1 2011-C Station 6 2011-J Station 2 2011-H Station 7 BC4 ERA 5 2011-F Station 5 183 BC5 2012-H 2011-A 2012-P 184 2012-K 2012-F 84 83 Station 3 T7a T8b T11 T19 T1 T18 ERA 12 T15 T16 T17 T3 T4 T5 T6
Station

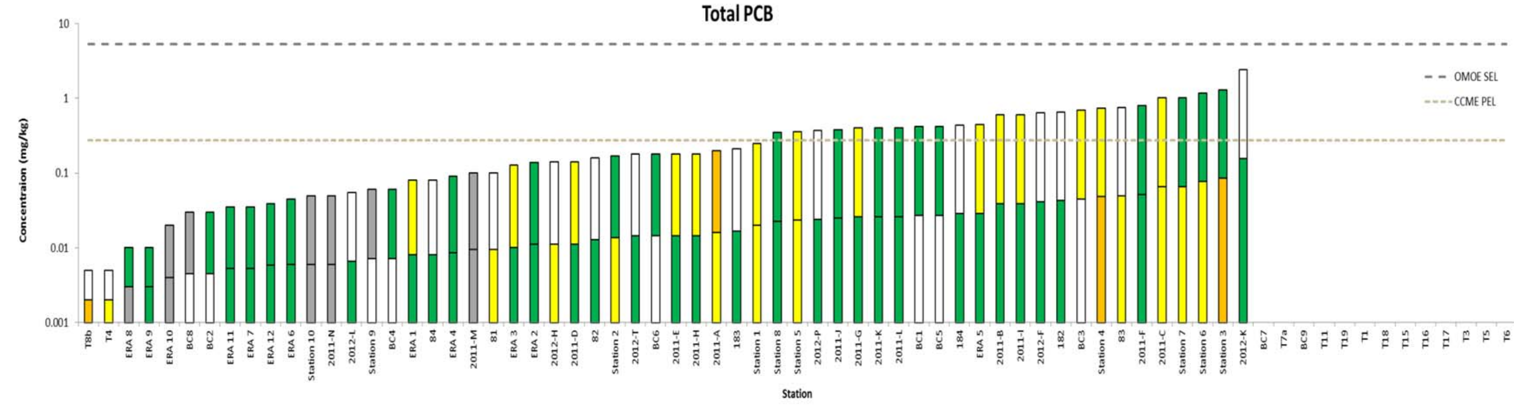

Mercury
Concentraion (mg/kg)
0 0.5 1 1.5 2 2.5
OMOE SEL
CCME PEL
2012-L Station 10 81 2012-T 2011-N 2011-M Station 9 82 Station 8 BC6 BC8 Station 2 2011-E BC1 2011-D 2012-F 2011-L 182 2011-K 2012-H 2012-P 2011-I 83 Station 1 2011-A BC7 BC9 2011-G BC3 BC4 84 2011-C 2011-J Station 4 2011-B 2012-K Station 6 Station 7 2011-H 2011-F BC5 BC2 Station 3 Station 5 184 ERA 11 T7a T8b ERA 8 ERA 9 T11 T19 ERA 10 T1 ERA 1 ERA 2 ERA 3 ERA 4 ERA 6 ERA 7 183 T18 ERA 12 ERA 5 T15 T16 T17 T3 T4 T5 T6
Station


Nickel
Concentraion (mg/kg)
Station
OMOE SEL
OMOE LEL


Silver
Concentraion (mg/kg)
Station
LAET
2LAET


Zinc
Concentraion (mg/kg)
Station
OMOE SEL
CCME PEL


Total PAH
Concentraion (mg/kg)
Station
OMOE SEL
OMOE LEL


Total PCB
Concentraion (mg/kg)
Station
OMOE SEL
CCME PEL

APPENDIX B

Wildlife Risk Model—Refined Calculations

Table B-1: Summary of Exposure Point Concentrations in Sediment, for Individual Management Units and Combined Units Based on Foraging Ranges

Note: 90th pecentile values from IDW surface used as sediment EPCs. Other percentiles shown for context.

		Total PAH (mg/kg)					Total PCB (mg/kg)					Antimony (mg/kg)					Arsenic (mg/kg)					Chromium (mg/kg)				
Individual Management Units	Area (ha)	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile
PC-N	124.5	1.8	1.0	2.2	4.3	5.3	0.03	0.01	0.04	0.05	0.06	NA	NA	NA	NA	NA	2.5	2.1	2.8	3.0	3.5	68	44	84	110	150
TC-E	83.6	2.4	1.4	3.0	4.0	4.9	0.12	0.05	0.13	0.23	0.36	NA	NA	NA	NA	NA	3.3	2.8	3.7	4.4	4.8	209	111	278	385	480
PC-E	9.5	6.0	3.5	7.6	12.2	12.9	0.18	0.08	0.23	0.36	0.39	1.9	0.5	2.5	4.1	7.2	4.5	3.8	5.1	6.8	6.9	890	689	946	1227	1953
PC-W	7.3	20.4	10.4	24.9	42.7	48.5	0.55	0.22	0.67	1.40	1.83	3.0	2.2	3.7	4.1	4.6	6.9	5.0	8.7	10.0	11.8	3209	1533	4800	6176	7456
TC-OM	2.6	4.7	2.9	6.0	8.5	9.5	0.19	0.12	0.24	0.29	0.34	2.2	1.1	1.8	4.8	7.4	11.0	8.4	12.5	16.3	20.4	1208	957	1532	1655	1695
TC-RC	3.6	37.7	4.6	31.3	38.9	138.6	0.39	0.30	0.45	0.53	0.66	6.6	1.0	10.8	13.9	18.7	79.5	14.4	73.8	207.9	421.0	782	613	931	1364	1641
WM	1.9	16.1	7.5	20.2	36.3	38.6	0.45	0.34	0.55	0.63	0.79	1.0	0.2	0.9	2.7	5.6	34.0	16.0	55.3	69.0	75.0	880	847	1050	1070	1087
TC-1	26.1	3.4	2.1	3.9	5.7	6.0	0.42	0.21	0.61	0.75	0.85	1.8	0.6	1.2	3.9	7.5	6.2	5.0	6.4	8.3	11.4	902	743	1021	1155	1199
TC-2A	5.1	5.1	3.2	5.5	9.8	11.1	0.38	0.31	0.47	0.55	0.58	1.2	1.1	1.4	1.4	1.7	15.4	10.7	18.5	22.1	30.0	522	275	824	908	920
TC-2B	8.2	3.7	2.3	4.5	5.2	5.4	0.57	0.45	0.76	0.81	0.81	3.0	0.5	2.7	11.5	15.4	6.5	5.2	6.8	9.9	10.6	691	581	776	921	963
TC-3A	4.1	5.2	3.2	5.7	8.5	12.5	0.53	0.41	0.58	0.86	1.10	1.0	0.8	1.1	1.5	1.6	13.4	7.7	16.1	25.1	30.2	597	470	672	864	904
TC-3B	3.1	3.3	2.0	4.3	5.3	6.8	0.58	0.38	0.80	0.92	1.12	1.6	0.5	0.7	2.7	9.5	5.8	5.3	6.1	6.8	7.0	513	398	598	715	750
TC-4	4.2	11.3	5.4	14.4	21.4	26.3	0.59	0.36	0.73	1.17	1.24	0.9	0.7	1.1	1.3	1.7	9.3	7.0	10.1	14.0	19.0	392	330	470	538	585
TC-5	9.2	6.2	2.4	7.7	11.3	17.9	0.22	0.15	0.29	0.36	0.42	1.5	0.5	1.0	4.5	5.7	4.6	3.9	5.4	5.5	5.9	212	174	260	306	339
TC-AB	4.4	8.6	4.1	10.8	16.0	16.5	0.31	0.17	0.37	0.53	0.71	2.0	0.9	1.8	3.7	9.6	6.6	5.3	7.5	9.2	9.6	244	184	321	359	377
		Total PAH (mg/kg)					Total PCB (mg/kg)					Antimony (mg/kg)					Arsenic (mg/kg)					Chromium (mg/kg)				
Combined Management Units	Area (ha)	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile
TC-OM + PC-W	9.8	16.3	6.0	21.5	35.8	46.3	0.46	0.17	0.51	1.14	1.63	2.8	1.7	3.7	4.2	5.1	8.0	5.6	9.3	12.3	13.3	2689	1207	3963	5595	6616
TC-RC + TC-1	29.7	7.6	2.1	4.5	8.1	16.1	0.45	0.27	0.63	0.74	0.85	2.3	0.6	1.6	6.9	11.5	14.9	5.1	7.0	15.3	48.4	887	723	1016	1159	1224
WM + TC-2A + TC-2B	15.2	5.7	3.0	5.3	10.6	17.4	0.49	0.37	0.62	0.79	0.81	2.2	0.6	1.4	6.0	12.2	12.9	5.5	14.3	22.1	37.5	658	539	876	960	1014
TC-3A, TC-3B, TC-4	11.5	8.4	5.0	11.3	12.1	19.5	0.57	0.38	0.69	1.03	1.15	1.1	0.6	1.1	1.4	1.7	9.8	6.1	11.7	16.9	21.9	498	370	602	721	819
TC-AB, TC-5	13.6	6.9	3.1	8.9	14.5	17.3	0.25	0.15	0.31	0.41	0.47	1.6	0.5	1.6	4.5	6.4	5.3	4.0	6.1	7.2	8.4	222	178	275	330	360
All Western KIH	89.2	7.9	2.7	7.8	14.6	21.5	0.41	0.20	0.55	0.75	0.88	2.0	0.6	1.8	4.6	8.7	10.6	5.0	8.6	14.6	22.0	896	438	965	1289	2160

		Copper (mg/kg)					Lead (mg/kg)					Mercury (mg/kg)					Silver (mg/kg)					Zinc (mg/kg)				
Individual Management Units	Area (ha)	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile
PC-N	124.5	31.8	28.2	32.0	35.7	53.5	51.4	31.2	52.6	69.9	109.3	NA	NA	NA	NA	NA	0.36	0.25	0.48	0.50	0.50	192	95	128	245	501
TC-E	83.6	36.5	33.4	39.1	40.7	43.9	58.7	46.4	66.3	79.7	92.8	NA	NA	NA	NA	NA	0.49	0.50	0.50	0.50	0.50	141	133	146	157	160
PC-E	9.5	37.3	33.1	42.6	47.3	51.5	96.3	71.7	111.7	142.6	181.3	0.19	0.16	0.25	0.26	0.30	0.32	0.28	0.35	0.47	0.49	145	124	154	184	241
PC-W	7.3	67.4	45.3	82.5	104.7	110.0	252.1	167.6	341.4	389.1	437.0	0.34	0.26	0.40	0.54	0.56	0.64	0.42	0.80	0.85	0.95	274	194	336	371	426
TC-OM	2.6	41.8	37.4	44.8	47.0	49.5	129.2	113.0	141.1	172.0	179.2	0.46	0.29	0.61	0.75	0.98	0.59	0.45	0.64	0.99	1.19	165	152	175	190	191
TC-RC	3.6	56.7	47.3	53.7	69.9	112.3	165.6	125.5	175.3	213.8	342.9	1.33	0.56	1.65	2.72	4.14	2.08	0.94	1.95	5.03	8.61	197	177	210	230	235
WM	1.9	79.1	59.0	88.0	106.3	146.9	233.4	160.0	249.1	398.3	580.8	1.51	0.73	1.63	2.89	4.11	1.35	1.12	1.39	1.90	2.15	268	219	317	374	404
TC-1	26.1	43.0	39.0	45.8	51.6	60.3	111.9	98.3	126.0	134.2	141.5	0.34	0.23	0.36	0.61	0.81	0.59	0.43	0.81	0.92	1.01	161	150	173	189	194
TC-2A	5.1	67.2	57.3	73.9	82.6	90.1	148.5	139.7	164.0	189.6	195.0	1.09	0.76	1.36	1.51	1.67	2.01	1.35	2.51	2.85	3.62	363	240	316	498	889
TC-2B	8.2	55.8	47.8	56.9	82.4	91.9	117.3	99.0	132.9	147.4	149.7	0.35	0.27	0.45	0.53	0.55	0.88	0.74	1.08	1.23	1.29	184	170	197	211	219
TC-3A	4.1	58.5	51.0	63.9	73.4	76.0	154.2	121.3	180.0	211.2	225.6	0.80	0.49	1.05	1.40	1.47	1.14	0.89	1.28	1.50	1.66	220	190	245	270	279
TC-3B	3.1	46.4	43.2	49.2	50.9	51.0	100.3	86.6	109.8	125.2	129.3	0.31	0.25	0.34	0.42	0.45	0.71	0.58	0.80	0.93	0.99	176	165	181	189	192
TC-4	4.2	56.2	49.0	64.6	66.1	67.0	171.6	120.5	179.2	275.3	423.5	0.74	0.41	1.04	1.36	1.44	0.79	0.65	1.00	1.10	1.20	223	162	269	335	404
TC-5	9.2	45.4	43.0	45.0	52.5	60.0	78.7	64.3	83.5	112.5	127.9	0.22	0.18	0.25	0.27	0.33	0.49	0.49	0.50	0.55	0.60	153	147	160	161	163
TC-AB	4.4	124.5	54.3	116.7	270.5	428.8	126.9	100.2	153.7	198.3	214.4	0.30	0.27	0.36	0.38	0.44	0.63	0.58	0.73	0.79	0.81	235	188	296	369	415
		Copper (mg/kg)					Lead (mg/kg)					Mercury (mg/kg)					Silver (mg/kg)					Zinc (mg/kg)				
Combined Management Units	Area (ha)	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile	Average	25th Percentile	75th Percentile	90th Percentile	95th Percentile
TC-OM + PC-W	9.8	60.8	41.9	78.1	95.4	109.5	215.9	132.8	293.8	380.0	427.5	0.37	0.27	0.44	0.57	0.66	0.63	0.43	0.79	0.85	1.10	246	167	324	350	416
TC-RC + TC-1	29.7	44.7	39.0	47.0	54.4	61.1	118.3	99.8	129.6	145.6	168.9	0.46	0.23	0.46	0.86	1.27	0.77	0.43	0.90	1.08	1.47	166	151	180	192	204
WM + TC-2A + TC-2B	15.2	62.5	50.7	72.0	87.5	92.7	142.2	105.2	154.1	188.1	213.5	0.74	0.28	0.96	1.48	1.63	1.32	0.80	1.50	2.41	2.80	255	180	252	326	398
TC-3A, TC-3B, TC-4	11.5	54.4	48.0	62.1	66.3	72.6	146.1	103.5	160.5	210.4	230.0	0.65	0.36	0.92	1.37	1.42	0.89	0.66	1.10	1.28	1.32	209	176	237	278	317
TC-AB, TC-5	13.6	70.9	43.0	59.4	95.2	207.3	94.2	68.7	110.2	139.9	170.3	0.24	0.19	0.28	0.36	0.38	0.54	0.49	0.60	0.72	0.75	180	154	185	277	321
All Western KIH	89.2	53.9	40.5	57.0	74.0	88.8	130.7	95.8	143.5	191.8	249.7	0.46	0.24	0.50	0.96	1.36	0.8	0.45	0.9	1.3	1.7	195	154	201	281	333

Table B-2a: Mink Food Web Model Using Inputs from RMC-ESG Table IV-25

Dose Based on Wet Weight Approximations

Abbreviation	Parameter	Units	**As**	**Cr**	**Cu**	**Hg (sed)**	**MeHg (tissue)**	**Pb**	**Zn**	**Sb**	**PCB**	**TotalPAH**
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
EPCw	Water Concentration	mg/L	0	3.1	0.04	0	0	0.17	0.76	0	0.019	0.0003
EPCsed	Sediment Concentration	mg/kg dw	43	3893	53	1.7	0	215	207	42	0.98	835
EPCsed	Sediment Concentration	mg/kg ww	8.6	778.6	10.6	0.34	0	43	41.4	8.4	0.196	167
EPCfish	Fish Concentration	mg/kg dw	0.475	3.2	3.55	0	0.345	1.4	100	0.4	3.1	0.325
EPCfish	Fish Concentration	mg/kg ww	0.095	0.64	0.71	0	0.069	0.28	20	0.08	0.62	0.065
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	0	0	7.4	33	0.43	0	0.68
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0	0	0.74	3.3	0.043	0	0.068
EPCinv	Invertebrate Concentration	mg/kg dw	0	260	0	0	0	0	0	0	1.4	0.12
EPCinv	Invertebrate Concentration	mg/kg ww	0	46.8	0	0	0	0	0	0	0.252	0.0216
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	0	0
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	0	0
BW	Body weight	kg	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
FIR	Food ingestion-wet	kg ww food/kgBW-day	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
FIR	Food ingestion-wet	kg ww food/day	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148
FIR	Food ingestion-dry	kg dw food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FIR	Food ingestion-dry	kg dw food/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
WIR	Water ingestion	L/kgBW/day	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
WIR	Water ingestion	L/day	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246
F1	Sediment ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
F2	Fish ingestion	%FIR ww	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
F3	Macrophyte ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
F4	Invertebrate ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
F5	Other item ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ED	Exposure Duration	%Presence	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EPCdiet	Weighted Dietary	mg/kg ww food	0.095	0.64	0.71	0	0.069	0.28	20	0.08	0.62	0.065
Ddiet	Dose dietary	mg/kgBW-day	0.013	0.090	0.099	0.000	0.010	0.039	2.800	0.011	0.087	0.009
Dwater	Dose water	mg/kgBW-day	0.000	0.093	0.001	0.000	0.000	0.005	0.023	0.000	0.001	0.000
Dtotal	Dose all	mg/kgBW-day	0.013	0.183	0.101	0.000	0.010	0.044	2.823	0.011	0.087	0.009
Adj	Site Use Adjustment	fraction	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
EDI	Dose all - adjusted	mg/kgBW-day	0.013	0.183	0.101	0.000	0.010	0.044	2.823	0.011	0.087	9.1E-03
TRV	RMC-ESG Table IV-28	mg/kg-day	1.04	2.4	5.6	0.016	0.081	4.7	75.4	0.059	0.053	51.8
TRV lower	Golder 2012	mg/kg-day	-	46	-	-	-	-	-	-	0.082	-
TRV upper	Golder 2012	mg/kg-day	-	280	-	-	-	-	-	-	0.105	-
HQ	Hazard Quotient	Unitless	0.013	0.076	0.018	0.00	0.12	0.01	0.04	0.19	1.65	0.0002
HQ	HQ (Golder Lower TRV)	Unitless	-	0.004	-	-	-	-	-	-	1.07	-
HQ	HQ (Golder Upper TRV)	Unitless	-	0.001	-	-	-	-	-	-	0.83	-

Table B-2b: Mink Food Web Model - Revised Using Sediment Inputs from Management Units PC-W and TC-OM

Dose Based on Wet Weight Approximations

Abbreviation	Parameter	Units	**As**	**Cr**	**Cu**	**Hg (sed)**	**MeHg (tissue)**	**Pb**	**Zn**	**Sb**	**PCB**	**TotalPAH**	**Notes**
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0	0	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	12.3	5595	95.4	0.57	0	380	350	4.2	1.1	35.8	90th percentile of IDW smoothed data for TC-OM and PC-W combined
EPCsed	Sediment Concentration	mg/kg ww	2.5	1119	19.1	0.11	0	76	70	0.8	0.2	7.2	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.14	4.60	6.39	0.00	0.12	2.47	169.0	0.04	3.61	0.014	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.03	0.92	1.28	0.00	0.02	0.49	33.8	0.01	0.72	0.003	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	0	0	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0	0	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	0	374	0	0	0	0	0	0	1.63	0.005	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0	67	0	0	0	0	0	0	0.29	0.001	Calculated
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	0	0	
BW	Body weight	kg	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
FIR	Food ingestion-wet	kg ww food/kgBW-day	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	
FIR	Food ingestion-wet	kg ww food/day	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148	
FIR	Food ingestion-dry	kg dw food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
WIR	Water ingestion	L/kgBW/day	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	
WIR	Water ingestion	L/day	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246	
F1	Sediment ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F2	Fish ingestion	%FIR ww	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
F3	Macrophyte ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F4	Invertebrate ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F5	Other item ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
ED	Exposure Duration	%Presence	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
EPCdiet	Weighted Dietary	mg/kg ww food	0.027	0.920	1.278	0.000	0.023	0.495	33.804	0.008	0.722	0.003	
Ddiet	Dose dietary	mg/kgBW-day	0.004	0.129	0.179	0.000	0.003	0.069	4.733	0.001	0.101	0.000	
Dwater	Dose water	mg/kgBW-day	0.000	0.093	0.001	0.000	0.000	0.005	0.023	0.000	0.001	0.000	
Dtotal	Dose all	mg/kgBW-day	0.004	0.222	0.180	0.000	0.003	0.074	4.755	0.001	0.102	0.000	
Adj	Site Use Adjustment	fraction	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
EDI	Dose all - adjusted	mg/kgBW-day	0.004	0.222	0.180	0.000	0.003	0.074	4.755	0.001	0.102	4.0E-04	
TRV	RMC-ESG Table IV-28	mg/kg-day	1.04	2.4	5.6	0.016	0.081	4.7	75.4	0.059	0.053	51.8	
TRV lower	Golder 2012	mg/kg-day	-	46	-	-	-	-	-	-	0.082	-	
TRV upper	Golder 2012	mg/kg-day	-	280	-	-	-	-	-	-	0.105	-	
HQ	Hazard Quotient	Unitless	0.00	0.092	0.03	0.00	0.04	0.02	0.06	0.02	1.92	0.00	
HQ	HQ (Golder Lower TRV)	Unitless	-	0.005	-	-	-	-	-	-	1.24	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.001	-	-	-	-	-	-	0.97	-	

Table B-2c: Mink Food Web Model - Revised Using Sediment Inputs from Management Unit PC-E

Dose Based on Wet Weight Approximations

Abbreviation	Parameter	Units	**As**	**Cr**	**Cu**	**Hg (sed)**	**MeHg (tissue)**	**Pb**	**Zn**	**Sb**	**PCB**	**TotalPAH**	**Notes**
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0	0	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	6.8	1227	47.3	0.26	0	143	184	4.1	0.4	12.2	90th percentile of IDW smoothed data for PC-E
EPCsed	Sediment Concentration	mg/kg ww	1.4	245	9.5	0.05	0	29	37	0.8	0.1	2.4	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.075	1.01	3.17	0.00	0.054	0.93	88.97	0.039	1.12	0.005	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.015	0.20	0.63	0.00	0.011	0.19	17.8	0.008	0.22	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	0	0	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0	0	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	0	82	0	0	0	0	0	0	0.51	0.002	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0	15	0	0	0	0	0	0	0.09	0.000	Calculated
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	0	0	
BW	Body weight	kg	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
FIR	Food ingestion-wet	kg ww food/kgBW-day	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	
FIR	Food ingestion-wet	kg ww food/day	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148	0.1148	
FIR	Food ingestion-dry	kg dw food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
WIR	Water ingestion	L/kgBW/day	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	
WIR	Water ingestion	L/day	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246	0.0246	
F1	Sediment ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F2	Fish ingestion	%FIR ww	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
F3	Macrophyte ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F4	Invertebrate ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F5	Other item ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
ED	Exposure Duration	%Presence	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
EPCdiet	Weighted Dietary	mg/kg ww food	0.0149	0.2017	0.6341	0.0000	0.0108	0.1857	17.7948	0.0078	0.2248	0.0009	
Ddiet	Dose dietary	mg/kgBW-day	0.002	0.028	0.089	0.000	0.002	0.026	2.491	0.001	0.031	0.000	
Dwater	Dose water	mg/kgBW-day	0.000	0.093	0.001	0.000	0.000	0.005	0.023	0.000	0.001	0.000	
Dtotal	Dose all	mg/kgBW-day	0.002	0.121	0.090	0.000	0.002	0.031	2.514	0.001	0.032	0.000	
Adj	Site Use Adjustment	fraction	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
EDI	Dose all - adjusted	mg/kgBW-day	0.002	0.121	0.090	0.000	0.002	0.031	2.514	0.001	0.032	1.4E-04	
TRV	RMC-ESG Table IV-28	mg/kg-day	1.04	2.4	5.6	0.016	0.081	4.7	75.4	0.059	0.053	51.8	
TRV lower	Golder 2012	mg/kg-day	-	46	-	-	-	-	-	-	0.082	-	
TRV upper	Golder 2012	mg/kg-day	-	280	-	-	-	-	-	-	0.105	-	
HQ	Hazard Quotient	Unitless	0.00	0.051	0.02	0.00	0.02	0.01	0.03	0.02	0.60	0.00	
HQ	HQ (Golder Lower TRV)	Unitless	-	0.003	-	-	-	-	-	-	0.39	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.000	-	-	-	-	-	-	0.31	-	

Table B-3a: Mallard Duck Food Web Model Using Inputs from RMC-ESG Table IV-25

Dose Based on Dry Weight Approximations

			As	Cr	Cu	Hg (sed)	MeHg (tissue)	Pb	Zn	Sb	PCB	TotalPAH
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
EPCw	Water Concentration	mg/L	0	3.1	0.04	0	0	0.17	0.76	0	0.019	0.0003
EPCsed	Sediment Concentration	mg/kg dw	43	3893	53	1.7	0	215	207	42	0.98	835
EPCsed	Sediment Concentration	mg/kg ww	8.6	778.6	10.6	0.34	0	43	41.4	8.4	0.196	167
EPCfish	Fish Concentration	mg/kg dw	0.475	3.2	3.55	0	0.345	1.4	100	0.4	3.1	0.325
EPCfish	Fish Concentration	mg/kg ww	0.095	0.64	0.71	0	0.069	0.28	20	0.08	0.62	0.065
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	0	0	7.4	33	0.43	0	0.68
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0	0	0.74	3.3	0.043	0	0.068
EPCinv	Invertebrate Concentration	mg/kg dw	0	260	0	0	0	0	0	0	1.4	0.12
EPCinv	Invertebrate Concentration	mg/kg ww	0	46.8	0	0	0	0	0	0	0.252	0.0216
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	0	0
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	0	0
BW	Body weight	kg	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
FIR	Food ingestion-wet	kg ww food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FIR	Food ingestion-wet	kg ww food/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FIR	Food ingestion-dry	kg dw food/kgBW-day	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
FIR	Food ingestion-dry	kg dw food/day	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
WIR	Water ingestion	L/kgBW/day	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
WIR	Water ingestion	L/day	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072
F1	Sediment ingestion	%FIR dw	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
F2	Fish ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
F3	Macrophyte ingestion	%FIR dw	97%	0%	97%	97%	97%	97%	97%	0%	0%	0%
F4	Invertebrate ingestion	%FIR dw	0%	97%	0%	0%	0%	0%	0%	97%	97%	97%
F5	Other item ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ED	Exposure Duration	%Presence	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
EPCdiet	Weighted Dietary	mg/kg dw food	2.939	368.99	9.156	0.051	0	13.628	38.22	1.26	1.3874	25.1664
Ddiet	Dose dietary	mg/kgBW-day	0.147	18.450	0.458	0.003	0.000	0.681	1.911	0.063	0.069	1.258
Dwater	Dose water	mg/kgBW-day	0.000	0.186	0.002	0.000	0.000	0.010	0.046	0.000	0.001	0.000
Dtotal	Dose all	mg/kgBW-day	0.147	18.636	0.460	0.003	0.000	0.692	1.957	0.063	0.071	1.258
Adj	Site Use Adjustment	fraction	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
EDI	Dose all - adjusted	mg/kgBW-day	0.087	10.995	0.272	0.0015	0.000	0.408	1.154	0.037	0.042	0.742
TRV	RMC-ESG Table IV-28	mg/kg-day	2.24	2.66	4.05	0.013	0.029	1.63	66.1	NA	0.18	1.7
TRV lower	Golder 2012	mg/kg-day		5							0.26	
TRV upper	Golder 2012	mg/kg-day		100							1.8	
HQ	Hazard Quotient	Unitless	0.039	4.1	0.067	0.12	0.00	0.25	0.02	NA	0.23	0.44
HQ	HQ (Golder Lower TRV)	Unitless	-	2.2	-	-	-	-	-	-	0.16	-
HQ	HQ (Golder Upper TRV)	Unitless	-	0.1	-	-	-	-	-	-	0.02	-

Table B-3b: Mallard Duck Food Web Model Using Inputs from Management Units PC-W and TC-OM

Dose Based on Dry Weight Approximations

			As	Cr	Cu	Hg (sed)	MeHg (tissue)	Pb	Zn	Sb	PCB	TotalPAH	Notes
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0	0	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	12.3	5595	95.4	0.57	0	380	350	4.2	1.1	35.8	90th percentile of IDW smoothed data for TC-OM and PC-W combined
EPCsed	Sediment Concentration	mg/kg ww	2.5	1119	19.1	0.11	0.0	76	70	0.83	0.23	7.2	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.14	4.60	6.39	0.00	0.12	2.47	169	0.04	3.61	0.014	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.03	0.92	1.28	0.00	0.02	0.49	33.8	0.01	0.72	0.003	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	0	0	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0	0	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	0	374	0	0	0	0	0	0	1.63	0.005	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0	67.3	0	0	0	0	0	0	0.29	0.001	Calculated
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	0	0	
BW	Body weight	kg	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	Revised to match FCSAP guidance (Appendix C)
FIR	Food ingestion-wet	kg ww food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-wet	kg ww food/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/kgBW-day	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	
FIR	Food ingestion-dry	kg dw food/day	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	
WIR	Water ingestion	L/kgBW/day	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	Revised to match FCSAP guidance (Appendix C)
WIR	Water ingestion	L/day	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	
F1	Sediment ingestion	%FIR dw	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	
F2	Fish ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F3	Macrophyte ingestion	%FIR dw	97%	49%	97%	97%	97%	97%	97%	49%	97%	49%	Diet split evenly between macrophytes/invertebrates for some COPCs
F4	Invertebrate ingestion	%FIR dw	0%	49%	0%	0%	0%	0%	0%	49%	0%	49%	Diet split considered Expert Support feedback
F5	Other item ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
ED	Exposure Duration	%Presence	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	
EPCdiet	Weighted Dietary	mg/kg dw food	2.018	361.217	10.427	0.017	0.000	18.579	42.506	0.333	0.034	1.405	
Ddiet	Dose dietary	mg/kgBW-day	0.101	18.061	0.521	0.001	0.000	0.929	2.125	0.017	0.002	0.070	
Dwater	Dose water	mg/kgBW-day	0.000	0.186	0.002	0.000	0.000	0.010	0.046	0.000	0.001	0.000	
Dtotal	Dose all	mg/kgBW-day	0.101	18.247	0.524	0.001	0.000	0.939	2.171	0.017	0.003	0.070	
Adj	Site Use Adjustment	fraction	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	
EDI	Dose all - adjusted	mg/kgBW-day	0.060	10.766	0.309	0.0005	0.000	0.554	1.281	0.010	0.002	0.041	
TRV	RMC-ESG Table IV-28	mg/kg-day	2.24	2.66	4.05	0.013	0.029	1.63	66.1	NA	0.18	1.7	
TRV lower	Golder 2012	mg/kg-day		5							0.26		
TRV upper	Golder 2012	mg/kg-day		100							1.8		
HQ	Hazard Quotient	Unitless	0.027	4.0	0.076	0.04	0.00	0.34	0.02	NA	0.01	0.02	
HQ	HQ (Golder Lower TRV)	Unitless	-	2.2	-	-	-	-	-	-	0.01	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.1	-	-	-	-	-	-	0.00	-	

Table B-3c: Mallard Duck Food Web Model Using Inputs from Management Unit PC-E

Dose Based on Dry Weight Approximations

			As	Cr	Cu	Hg (sed)	MeHg (tissue)	Pb	Zn	Sb	PCB	TotalPAH	Notes
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0	0	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	6.8	1227	47.3	0.26	0	143	184	4.1	0.4	12.2	90th percentile of IDW smoothed data for PC-E
EPCsed	Sediment Concentration	mg/kg ww	1.4	245	9.5	0.05	0	29	37	0.8	0.1	2.4	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.075	1.01	3.17	0.00	0.054	0.93	88.97	0.039	1.12	0.005	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.015	0.20	0.63	0.00	0.011	0.19	17.8	0.008	0.22	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	0	0	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0	0	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	0	82	0	0	0	0	0	0	0.51	0.002	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0	15	0	0	0	0	0	0	0.09	0.000	Calculated
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	0	0	
BW	Body weight	kg	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	Revised to match FCSAP guidance (Appendix C)
FIR	Food ingestion-wet	kg ww food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-wet	kg ww food/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/kgBW-day	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	
FIR	Food ingestion-dry	kg dw food/day	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	
WIR	Water ingestion	L/kgBW/day	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	Revised to match FCSAP guidance (Appendix C)
WIR	Water ingestion	L/day	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	
F1	Sediment ingestion	%FIR dw	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	
F2	Fish ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F3	Macrophyte ingestion	%FIR dw	97%	49%	97%	97%	97%	97%	97%	49%	97%	49%	Diet split evenly between macrophytes/invertebrates for some COPCs
F4	Invertebrate ingestion	%FIR dw	0%	49%	0%	0%	0%	0%	0%	49%	0%	49%	Diet split considered Expert Support feedback
F5	Other item ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
ED	Exposure Duration	%Presence	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	
EPCdiet	Weighted Dietary	mg/kg dw food	1.852	88.673	8.986	0.008	0.000	11.456	37.535	0.331	0.011	0.696	
Ddiet	Dose dietary	mg/kgBW-day	0.093	4.434	0.449	0.000	0.000	0.573	1.877	0.017	0.001	0.035	
Dwater	Dose water	mg/kgBW-day	0.000	0.186	0.002	0.000	0.000	0.010	0.046	0.000	0.001	0.000	
Dtotal	Dose all	mg/kgBW-day	0.093	4.620	0.452	0.000	0.000	0.583	1.922	0.017	0.002	0.035	
Adj	Site Use Adjustment	fraction	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	
EDI	Dose all - adjusted	mg/kgBW-day	0.055	2.726	0.267	0.0002	0.000	0.344	1.134	0.010	0.001	0.021	
TRV	RMC-ESG Table IV-28	mg/kg-day	2.24	2.66	4.05	0.013	0.029	1.63	66.1	NA	0.18	1.7	
TRV lower	Golder 2012	mg/kg-day		5							0.26		
TRV upper	Golder 2012	mg/kg-day		100							1.8		
HQ	Hazard Quotient	Unitless	0.024	1.02	0.066	0.02	0.00	0.21	0.02	NA	0.01	0.01	
HQ	HQ (Golder Lower TRV)	Unitless	-	0.55	-	-	-	-	-	-	0.00	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.03	-	-	-	-	-	-	0.00	-	

Table B-3d: Mallard Duck Food Web Model Using Inputs from Management Units TC-RC and TC-1

Dose Based on Dry Weight Approximations

			As	Cr	Cu	Hg (sed)	MeHg (tissue)	Pb	Zn	Sb	PCB	TotalPAH	Notes
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0	0	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	15.3	1159	54.4	0.86	0	146	192	6.9	0.7	8.1	90th percentile of IDW smoothed data for TC-RC and TC-1 combined
EPCsed	Sediment Concentration	mg/kg ww	3.1	232	10.9	0.17	0	29	38	1.4	0.1	1.6	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.169	0.95	3.64	0.00	0.176	0.95	92.72	0.066	2.35	0.003	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.034	0.19	0.73	0.00	0.035	0.19	18.5	0.013	0.47	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	0	0	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0	0	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	0	77	0	0	0	0	0	0	1.06	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0	14	0	0	0	0	0	0	0.19	0.000	Calculated
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	0	0	
BW	Body weight	kg	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	Revised to match FCSAP guidance (Appendix C)
FIR	Food ingestion-wet	kg ww food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-wet	kg ww food/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/kgBW-day	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	
FIR	Food ingestion-dry	kg dw food/day	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	
WIR	Water ingestion	L/kgBW/day	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	Revised to match FCSAP guidance (Appendix C)
WIR	Water ingestion	L/day	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	
F1	Sediment ingestion	%FIR dw	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	
F2	Fish ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F3	Macrophyte ingestion	%FIR dw	97%	49%	97%	97%	97%	97%	97%	49%	97%	49%	Diet split evenly between macrophytes/invertebrates for some COPCs
F4	Invertebrate ingestion	%FIR dw	0%	49%	0%	0%	0%	0%	0%	49%	0%	49%	Diet split considered Expert Support feedback
F5	Other item ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
ED	Exposure Duration	%Presence	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	
EPCdiet	Weighted Dietary	mg/kg dw food	2.109	84.424	9.197	0.026	0.000	11.545	37.768	0.416	0.022	0.573	
Ddiet	Dose dietary	mg/kgBW-day	0.105	4.221	0.460	0.001	0.000	0.577	1.888	0.021	0.001	0.029	
Dwater	Dose water	mg/kgBW-day	0.000	0.186	0.002	0.000	0.000	0.010	0.046	0.000	0.001	0.000	
Dtotal	Dose all	mg/kgBW-day	0.105	4.407	0.462	0.001	0.000	0.587	1.934	0.021	0.002	0.029	
Adj	Site Use Adjustment	fraction	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	
EDI	Dose all - adjusted	mg/kgBW-day	0.062	2.600	0.273	0.0008	0.000	0.347	1.141	0.012	0.001	0.017	
TRV	RMC-ESG Table IV-28	mg/kg-day	2.24	2.66	4.05	0.013	0.029	1.63	66.1	NA	0.18	1.7	
TRV lower	Golder 2012	mg/kg-day		5							0.26		
TRV upper	Golder 2012	mg/kg-day		100							1.8		
HQ	Hazard Quotient	Unitless	0.028	0.98	0.067	0.06	0.00	0.21	0.02	NA	0.01	0.01	
HQ	HQ (Golder Lower TRV)	Unitless	-	0.52	-	-	-	-	-	-	0.01	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.03	-	-	-	-	-	-	0.00	-	

Table B-3e: Mallard Duck Food Web Model Using Inputs from Management Units WM, TC2A, and TC2B

Dose Based on Dry Weight Approximations

			As	Cr	Cu	Hg (sed)	MeHg (tissue)	Pb	Zn	Sb	PCB	TotalPAH	Notes
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0	0	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	22.1	960	87.5	1.48	0	188	326	6.0	0.8	10.6	90th percentile of IDW smoothed data for WM, TC2A, and TC2B combined
EPCsed	Sediment Concentration	mg/kg ww	4.4	192	17.5	0.30	0	38	65	1.2	0.2	2.1	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.244	0.79	5.86	0.00	0.300	1.22	157.72	0.057	2.51	0.004	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.049	0.16	1.17	0.00	0.060	0.24	31.5	0.011	0.50	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	0	0	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0	0	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	0	64	0	0	0	0	0	0	1.13	0.002	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0	12	0	0	0	0	0	0	0.20	0.000	Calculated
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	0	0	
BW	Body weight	kg	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	Revised to match FCSAP guidance (Appendix C)
FIR	Food ingestion-wet	kg ww food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-wet	kg ww food/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/kgBW-day	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	
FIR	Food ingestion-dry	kg dw food/day	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	
WIR	Water ingestion	L/kgBW/day	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	Revised to match FCSAP guidance (Appendix C)
WIR	Water ingestion	L/day	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	
F1	Sediment ingestion	%FIR dw	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	
F2	Fish ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F3	Macrophyte ingestion	%FIR dw	97%	49%	97%	97%	97%	97%	97%	49%	97%	49%	Diet split evenly between macrophytes/invertebrates for some COPCs
F4	Invertebrate ingestion	%FIR dw	0%	49%	0%	0%	0%	0%	0%	49%	0%	49%	Diet split considered Expert Support feedback
F5	Other item ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
ED	Exposure Duration	%Presence	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	
EPCdiet	Weighted Dietary	mg/kg dw food	2.311	72.036	10.190	0.044	0.000	12.820	41.804	0.388	0.024	0.649	
Ddiet	Dose dietary	mg/kgBW-day	0.116	3.602	0.509	0.002	0.000	0.641	2.090	0.019	0.001	0.032	
Dwater	Dose water	mg/kgBW-day	0.000	0.186	0.002	0.000	0.000	0.010	0.046	0.000	0.001	0.000	
Dtotal	Dose all	mg/kgBW-day	0.116	3.788	0.512	0.002	0.000	0.651	2.136	0.019	0.002	0.032	
Adj	Site Use Adjustment	fraction	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	
EDI	Dose all - adjusted	mg/kgBW-day	0.068	2.235	0.302	0.0013	0.000	0.384	1.260	0.011	0.001	0.019	
TRV	RMC-ESG Table IV-28	mg/kg-day	2.24	2.66	4.05	0.013	0.029	1.63	66.1	NA	0.18	1.7	
TRV lower	Golder 2012	mg/kg-day		5							0.26		
TRV upper	Golder 2012	mg/kg-day		100							1.8		
HQ	Hazard Quotient	Unitless	0.030	0.8	0.075	0.10	0.00	0.24	0.02	NA	0.01	0.01	
HQ	HQ (Golder Lower TRV)	Unitless	-	0.4	-	-	-	-	-	-	0.01	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.02	-	-	-	-	-	-	0.00	-	

Table B-3f: Mallard Duck Food Web Model Using Inputs from Management Units TC-3A, TC-3B, and TC-4

Dose Based on Dry Weight Approximations

			As	Cr	Cu	Hg (sed)	MeHg (tissue)	Pb	Zn	Sb	PCB	TotalPAH	Notes
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0	0	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	16.9	721	66.3	1.37	0	210	278	1.4	1.0	12.1	90th percentile of IDW smoothed data for TC-3A, TC-3B, and TC-4 combined
EPCsed	Sediment Concentration	mg/kg ww	3.4	144	13.3	0.27	0	42	56	0.3	0.2	2.4	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.187	0.59	4.44	0.00	0.279	1.37	134.54	0.014	3.24	0.005	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.037	0.12	0.89	0.00	0.056	0.27	26.9	0.003	0.65	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	0	0	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0	0	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	0	48	0	0	0	0	0	0	1.46	0.002	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0	9	0	0	0	0	0	0	0.26	0.000	Calculated
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	0	0	
BW	Body weight	kg	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	Revised to match FCSAP guidance (Appendix C)
FIR	Food ingestion-wet	kg ww food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-wet	kg ww food/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/kgBW-day	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	
FIR	Food ingestion-dry	kg dw food/day	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	
WIR	Water ingestion	L/kgBW/day	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	Revised to match FCSAP guidance (Appendix C)
WIR	Water ingestion	L/day	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	
F1	Sediment ingestion	%FIR dw	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	
F2	Fish ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F3	Macrophyte ingestion	%FIR dw	97%	49%	97%	97%	97%	97%	97%	49%	97%	49%	Diet split evenly between macrophytes/invertebrates for some COPCs
F4	Invertebrate ingestion	%FIR dw	0%	49%	0%	0%	0%	0%	0%	49%	0%	49%	Diet split considered Expert Support feedback
F5	Other item ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
ED	Exposure Duration	%Presence	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	
EPCdiet	Weighted Dietary	mg/kg dw food	2.156	57.116	9.554	0.041	0.000	13.489	40.365	0.252	0.031	0.693	
Ddiet	Dose dietary	mg/kgBW-day	0.108	2.856	0.478	0.002	0.000	0.674	2.018	0.013	0.002	0.035	
Dwater	Dose water	mg/kgBW-day	0.000	0.186	0.002	0.000	0.000	0.010	0.046	0.000	0.001	0.000	
Dtotal	Dose all	mg/kgBW-day	0.108	3.042	0.480	0.002	0.000	0.685	2.064	0.013	0.003	0.035	
Adj	Site Use Adjustment	fraction	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	
EDI	Dose all - adjusted	mg/kgBW-day	0.064	1.795	0.283	0.0012	0.000	0.404	1.218	0.007	0.002	0.020	
TRV	RMC-ESG Table IV-28	mg/kg-day	2.24	2.66	4.05	0.013	0.029	1.63	66.1	NA	0.18	1.7	
TRV lower	Golder 2012	mg/kg-day		5							0.26		
TRV upper	Golder 2012	mg/kg-day		100							1.8		
HQ	Hazard Quotient	Unitless	0.028	0.7	0.070	0.09	0.00	0.25	0.02	NA	0.01	0.01	
HQ	HQ (Golder Lower TRV)	Unitless	-	0.4	-	-	-	-	-	-	0.01	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.0	-	-	-	-	-	-	0.00	-	

Table B-3g: Mallard Duck Food Web Model Using Inputs from Management Units TC-AB and TC-5

Dose Based on Dry Weight Approximations

			As	Cr	Cu	Hg (sed)	MeHg (tissue)	Pb	Zn	Sb	PCB	TotalPAH	Notes
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0	0	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	7.2	330	95.2	0.36	0	140	277	4.5	0.4	14.5	90th percentile of IDW smoothed data for TC-AB, and TC-5 combined
EPCsed	Sediment Concentration	mg/kg ww	1.4	66	19.0	0.07	0	28	55	0.9	0.1	2.9	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.079	0.27	6.38	0.00	0.073	0.91	133.70	0.043	1.30	0.006	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.016	0.05	1.28	0.00	0.015	0.18	26.7	0.009	0.26	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	0	0	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0	0	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	0	22	0	0	0	0	0	0	0.59	0.002	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0	4	0	0	0	0	0	0	0.11	0.000	Calculated
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	0	0	
BW	Body weight	kg	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	Revised to match FCSAP guidance (Appendix C)
FIR	Food ingestion-wet	kg ww food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-wet	kg ww food/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/kgBW-day	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	
FIR	Food ingestion-dry	kg dw food/day	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	
WIR	Water ingestion	L/kgBW/day	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	Revised to match FCSAP guidance (Appendix C)
WIR	Water ingestion	L/day	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	
F1	Sediment ingestion	%FIR dw	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	
F2	Fish ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F3	Macrophyte ingestion	%FIR dw	97%	49%	97%	97%	97%	97%	97%	49%	97%	49%	Diet split evenly between macrophytes/invertebrates for some COPCs
F4	Invertebrate ingestion	%FIR dw	0%	49%	0%	0%	0%	0%	0%	49%	0%	49%	Diet split considered Expert Support feedback
F5	Other item ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
ED	Exposure Duration	%Presence	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	
EPCdiet	Weighted Dietary	mg/kg dw food	1.864	32.707	10.422	0.011	0.000	11.376	40.313	0.343	0.012	0.765	
Ddiet	Dose dietary	mg/kgBW-day	0.093	1.635	0.521	0.001	0.000	0.569	2.016	0.017	0.001	0.038	
Dwater	Dose water	mg/kgBW-day	0.000	0.186	0.002	0.000	0.000	0.010	0.046	0.000	0.001	0.000	
Dtotal	Dose all	mg/kgBW-day	0.093	1.821	0.523	0.001	0.000	0.579	2.061	0.017	0.002	0.038	
Adj	Site Use Adjustment	fraction	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	
EDI	Dose all - adjusted	mg/kgBW-day	0.055	1.075	0.309	0.0003	0.000	0.342	1.216	0.010	0.001	0.023	
TRV	RMC-ESG Table IV-28	mg/kg-day	2.24	2.66	4.05	0.013	0.029	1.63	66.1	NA	0.18	1.7	
TRV lower	Golder 2012	mg/kg-day		5							0.26		
TRV upper	Golder 2012	mg/kg-day		100							1.8		
HQ	Hazard Quotient	Unitless	0.025	0.4	0.076	0.02	0.00	0.21	0.02	NA	0.01	0.01	
HQ	HQ (Golder Lower TRV)	Unitless	-	0.2	-	-	-	-	-	-	0.00	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.0	-	-	-	-	-	-	0.00	-	

Table B-4a: Great Blue Heron Food Web Model Using Inputs from RMC-ESG Table IV-25

Dose Based on Wet Weight Approximations

			As	Cr	Cu	Hg (sed)	MeHg (tissue)	Pb	Zn	Sb	PCB	TotalPAH
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
EPCw	Water Concentration	mg/L	0	3.1	0.04	0	0	0.17	0.76	0	0.019	0.0003
EPCsed	Sediment Concentration	mg/kg dw	43	3893	53	1.7	0	215	207	42	0.98	835
EPCsed	Sediment Concentration	mg/kg ww	8.6	778.6	10.6	0.34	0	43	41.4	8.4	0.196	167
EPCfish	Fish Concentration	mg/kg dw	0.475	3.2	3.55	0	0.345	1.4	100	0.4	3.1	0.325
EPCfish	Fish Concentration	mg/kg ww	0.095	0.64	0.71	0	0.069	0.28	20	0.08	0.62	0.065
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	0	0	7.4	33	0.43	0	0.68
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0	0	0.74	3.3	0.043	0	0.068
EPCinv	Invertebrate Concentration	mg/kg dw	0	260	0	0	0	0	0	0	1.4	0.12
EPCinv	Invertebrate Concentration	mg/kg ww	0	46.8	0	0	0	0	0	0	0.252	0.0216
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	0	0
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	0	0
BW	Body weight	kg	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
FIR	Food ingestion-wet	kg ww food/kgBW-day	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
FIR	Food ingestion-wet	kg ww food/day	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414
FIR	Food ingestion-dry	kg dw food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FIR	Food ingestion-dry	kg dw food/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
WIR	Water ingestion	L/kgBW/day	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
WIR	Water ingestion	L/day	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092
F1	Sediment ingestion	%FIR ww	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
F2	Fish ingestion	%FIR ww	100%	90%	100%	100%	100%	100%	100%	100%	90%	90%
F3	Macrophyte ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
F4	Invertebrate ingestion	%FIR ww	0%	10%	0%	0%	0%	0%	0%	0%	10%	10%
F5	Other item ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fsite	Proportion site use	%Site Use	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
ED	Exposure Duration	%Presence	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%
EPCdiet	Weighted Dietary	mg/kg ww food	0.267	20.828	0.922	0.0068	0.069	1.14	20.828	0.248	0.58712	3.40066
Ddiet	Dose dietary	mg/kgBW-day	0.048	3.749	0.166	0.001	0.012	0.205	3.749	0.045	0.106	0.612
Dwater	Dose water	mg/kgBW-day	0.000	0.124	0.002	0.000	0.000	0.007	0.030	0.000	0.001	0.000
Dtotal	Dose all	mg/kgBW-day	0.048	3.873	0.168	0.001	0.012	0.212	3.779	0.045	0.106	0.612
Adj	Site Use Adjustment	fraction	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
EDI	Dose all - adjusted	mg/kgBW-day	0.016	1.297	0.056	0.00041	0.0042	0.071	1.266	0.015	0.036	0.205
TRV	RMC-ESG Table IV-28	mg/kg-day	2.24	2.66	4.05	0.013	0.029	1.63	66.1	NA	0.18	1.7
TRV lower	Golder 2012	mg/kg-day		5							0.26	
TRV upper	Golder 2012	mg/kg-day		100							1.8	
HQ	Hazard Quotient	Unitless	0.007	0.488	0.014	0.03	0.14	0.04	0.02	NA	0.20	0.1206
HQ	HQ (Golder Lower TRV)	Unitless	-	0.259	-	-	-	-	-	-	0.14	-
HQ	HQ (Golder Upper TRV)	Unitless	-	0.013	-	-	-	-	-	-	0.02	-

Table B-4b: Great Blue Heron Food Web Model Using Inputs from Western KIH (all management units except PC-N and TC-E)

Dose Based on Wet Weight Approximations

			As	Cr	Cu	Hg (sed)	MeHg (tissue)	Pb	Zn	Sb	PCB	TotalPAH	Notes
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0	0	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	14.6	1289	74.0	0.96	0	192	281	4.6	0.8	14.6	90th percentile of IDW smoothed data for all Western KIH units combined
EPCsed	Sediment Concentration	mg/kg ww	2.92	257.74	14.80	0.19	0.00	38.36	56.17	0.93	0.15	2.92	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.16	1.06	4.96	0.00	0.19	1.25	135.67	0.04	2.37	0.01	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.032	0.21	0.99	0.00	0.039	0.25	27.1	0.009	0.47	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	0	0	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0	0	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	0	86	0	0	0	0	0	0	1.07	0.002	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0	15	0	0	0	0	0	0	0.19	0.000	Calculated
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	0	0	
BW	Body weight	kg	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	
FIR	Food ingestion-wet	kg ww food/kgBW-day	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	
FIR	Food ingestion-wet	kg ww food/day	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	
FIR	Food ingestion-dry	kg dw food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
WIR	Water ingestion	L/kgBW/day	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	
WIR	Water ingestion	L/day	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	
F1	Sediment ingestion	%FIR ww	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	
F2	Fish ingestion	%FIR ww	100%	90%	100%	100%	100%	100%	100%	100%	90%	90%	
F3	Macrophyte ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F4	Invertebrate ingestion	%FIR ww	0%	10%	0%	0%	0%	0%	0%	0%	10%	10%	
F5	Other item ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	
ED	Exposure Duration	%Presence	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%	
EPCdiet	Weighted Dietary	mg/kg ww food	0.091	6.895	1.287	0.004	0.039	1.017	28.257	0.027	0.449	0.059	
Ddiet	Dose dietary	mg/kgBW-day	0.016	1.241	0.232	0.001	0.007	0.183	5.086	0.005	0.081	0.011	
Dwater	Dose water	mg/kgBW-day	0.000	0.124	0.002	0.000	0.000	0.007	0.030	0.000	0.001	0.000	
Dtotal	Dose all	mg/kgBW-day	0.016	1.365	0.233	0.001	0.007	0.190	5.117	0.005	0.082	0.011	
Adj	Site Use Adjustment	fraction	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
EDI	Dose all - adjusted	mg/kgBW-day	0.005	0.457	0.078	0.00023	0.0023	0.064	1.714	0.002	0.027	0.004	
TRV	RMC-ESG Table IV-28	mg/kg-day	2.24	2.66	4.05	0.013	0.029	1.63	66.1	NA	0.18	1.7	
TRV lower	Golder 2012	mg/kg-day		5							0.26		
TRV upper	Golder 2012	mg/kg-day		100							1.8		
HQ	Hazard Quotient	Unitless	0.002	0.172	0.019	0.02	0.08	0.04	0.03	NA	0.15	0.0021	
HQ	HQ (Golder Lower TRV)	Unitless	-	0.091	-	-	-	-	-	-	0.11	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.005	-	-	-	-	-	-	0.02	-	

Table B-5a: Osprey Food Web Model Using Inputs from RMC-ESG Table IV-25

Dose Based on Wet Weight Approximations

			As	Cr	Cu	Hg (sed)	MeHg (tissue)	Pb	Zn	Sb	PCB	TotalPAH
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
EPCw	Water Concentration	mg/L	0	3.1	0.04	0	0	0.17	0.76	0	0.019	0.0003
EPCsed	Sediment Concentration	mg/kg dw	43	3893	53	1.7	0	215	207	42	0.98	835
EPCsed	Sediment Concentration	mg/kg ww	8.6	778.6	10.6	0.34	0	43	41.4	8.4	0.196	167
EPCfish	Fish Concentration	mg/kg dw	0.475	3.2	3.55	0	0.345	1.4	100	0.4	3.1	0.325
EPCfish	Fish Concentration	mg/kg ww	0.095	0.64	0.71	0	0.069	0.28	20	0.08	0.62	0.065
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	0	0	7.4	33	0.43	0	0.68
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0	0	0.74	3.3	0.043	0	0.068
EPCinv	Invertebrate Concentration	mg/kg dw	0	260	0	0	0	0	0	0	1.4	0.12
EPCinv	Invertebrate Concentration	mg/kg ww	0	46.8	0	0	0	0	0	0	0.252	0.0216
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	0	0
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	0	0
BW	Body weight	kg	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
FIR	Food ingestion-wet	kg ww food/kgBW-day	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
FIR	Food ingestion-wet	kg ww food/day	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775
FIR	Food ingestion-dry	kg dw food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FIR	Food ingestion-dry	kg dw food/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
WIR	Water ingestion	L/kgBW/day	0.0795	0.0795	0.0795	0.0795	0.0795	0.0795	0.0795	0.0795	0.0795	0.0795
WIR	Water ingestion	L/day	0.11925	0.11925	0.11925	0.11925	0.11925	0.11925	0.11925	0.11925	0.11925	0.11925
F1	Sediment ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
F2	Fish ingestion	%FIR ww	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
F3	Macrophyte ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
F4	Invertebrate ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
F5	Other item ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fsite	Proportion site use	%Site Use	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
ED	Exposure Duration	%Presence	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
EPCdiet	Weighted Dietary	mg/kg ww food	0.095	0.64	0.71	0	0.069	0.28	20	0.08	0.62	0.065
Ddiet	Dose dietary	mg/kgBW-day	0.037	0.246	0.273	0.000	0.027	0.108	7.700	0.031	0.239	0.025
Dwater	Dose water	mg/kgBW-day	0.000	0.246	0.003	0.000	0.000	0.014	0.060	0.000	0.002	0.000
Dtotal	Dose all	mg/kgBW-day	0.037	0.493	0.277	0.000	0.027	0.121	7.760	0.031	0.240	0.025
Adj	Site Use Adjustment	fraction	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
EDI	Dose all - adjusted	mg/kgBW-day	0.011	0.145	0.082	0.000	0.008	0.036	2.289	0.009	0.071	0.007
TRV	RMC-ESG Table IV-28	mg/kg-day	2.24	2.66	4.05	0.013	0.029	1.63	66.1	NA	0.18	1.7
TRV lower	Golder 2012	mg/kg-day		5							0.26	
TRV upper	Golder 2012	mg/kg-day		100							1.8	
HQ	Hazard Quotient	Unitless	0.005	0.055	0.020	0.00	0.27	0.02	0.03	NA	0.39	0.0043
HQ	HQ (Golder Lower TRV)	Unitless	-	0.029	-	-	-	-	-	-	0.27	-
HQ	HQ (Golder Upper TRV)	Unitless	-	0.001	-	-	-	-	-	-	0.04	-

Table B-5b: Osprey Food Web Model Using Inputs from Western KIH (all management units except PC-N and TC-E)

Dose Based on Wet Weight Approximations

			As	Cr	Cu	Hg (sed)	MeHg (tissue)	Pb	Zn	Sb	PCB	TotalPAH	Notes
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0	0	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	14.6	1289	74.0	0.96	0	192	281	4.6	0.8	14.6	90th percentile of IDW smoothed data for all Western KIH units combined
EPCsed	Sediment Concentration	mg/kg ww	2.92	257.74	14.80	0.19	0.00	38.36	56.17	0.93	0.15	2.92	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.16	1.06	4.96	0.00	0.19	1.25	135.67	0.04	2.37	0.01	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.032	0.21	0.99	0.00	0.039	0.25	27.1	0.009	0.47	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	0	0	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0	0	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	0	86	0	0	0	0	0	0	1.07	0.002	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0	15	0	0	0	0	0	0	0.19	0.000	Calculated
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	0	0	
BW	Body weight	kg	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	
FIR	Food ingestion-wet	kg ww food/kgBW-day	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	
FIR	Food ingestion-wet	kg ww food/day	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	
FIR	Food ingestion-dry	kg dw food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
WIR	Water ingestion	L/kgBW/day	0.0795	0.0795	0.0795	0.0795	0.0795	0.0795	0.0795	0.0795	0.0795	0.0795	
WIR	Water ingestion	L/day	0.1193	0.1193	0.1193	0.1193	0.1193	0.1193	0.1193	0.1193	0.1193	0.1193	
F1	Sediment ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F2	Fish ingestion	%FIR ww	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
F3	Macrophyte ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F4	Invertebrate ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
F5	Other item ingestion	%FIR ww	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	
ED	Exposure Duration	%Presence	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	
EPCdiet	Weighted Dietary	mg/kg ww food	0.032	0.212	0.991	0.000	0.039	0.250	27.133	0.009	0.475	0.001	
Ddiet	Dose dietary	mg/kgBW-day	0.012	0.082	0.382	0.000	0.015	0.096	10.446	0.003	0.183	0.000	
Dwater	Dose water	mg/kgBW-day	0.000	0.246	0.003	0.000	0.000	0.014	0.060	0.000	0.002	0.000	
Dtotal	Dose all	mg/kgBW-day	0.012	0.328	0.385	0.000	0.015	0.110	10.507	0.003	0.184	0.000	
Adj	Site Use Adjustment	fraction	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	
EDI	Dose all - adjusted	mg/kgBW-day	0.004	0.097	0.113	0.000	0.004	0.032	3.100	0.001	0.054	0.000	
TRV	RMC-ESG Table IV-28	mg/kg-day	2.24	2.66	4.05	0.013	0.029	1.63	66.1	NA	0.18	1.7	
TRV lower	Golder 2012	mg/kg-day		5							0.26		
TRV upper	Golder 2012	mg/kg-day		100							1.8		
HQ	Hazard Quotient	Unitless	0.002	0.036	0.028	0.00	0.15	0.02	0.05	NA	0.30	0.0001	
HQ	HQ (Golder Lower TRV)	Unitless	-	0.019	-	-	-	-	-	-	0.21	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.001	-	-	-	-	-	-	0.03	-	

Table B-6a: Muskrat Food Web Model Using Inputs from Management Unit PC-W

Dose Based on Dry Weight Approximations

			As	Cr	Cu	Pb	Zn	Sb	PCB	TotalPAH	Notes
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	12.3	5595	95.4	380	350	4.2	1.1	35.8	90th percentile of IDW smoothed data for PC-W
EPCsed	Sediment Concentration	mg/kg ww	2.5	1119	19.1	76	70	0.83	0.23	7.2	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.14	4.60	6.39	2.47	169	0.04	3.61	0.014	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.03	0.92	1.28	0.49	33.8	0.01	0.72	0.003	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	1.7	374	7.8	7.4	33	0.43	1.63	0.005	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0.306	67.3	1.404	1.332	5.94	0.0774	0.29	0.001	Calculated (assumed equal to macrophyte concentrations where no invertebrate estimates available)
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	
BW	Body weight	kg	1	1	1	1	1	1	1	1	Banfield 1974; Nagorsen 2005
FIR	Food ingestion-wet	kg ww food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-wet	kg ww food/day	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/kgBW-day	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	Campbell and MacArthur 1996
FIR	Food ingestion-dry	kg dw food/day	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	
WIR	Water ingestion	L/kgBW/day	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	Allometric equation from EPA 1993
WIR	Water ingestion	L/day	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
F1	Sediment ingestion	%FIR dw	2%	2%	2%	2%	2%	2%	2%	2%	Environment Canada (2012)
F2	Fish ingestion	%FIR dw	5%	5%	5%	5%	5%	5%	5%	5%	Environment Canada (2012)
F3	Macrophyte ingestion	%FIR dw	78%	78%	78%	78%	78%	78%	78%	78%	Environment Canada (2012)
F4	Invertebrate ingestion	%FIR dw	15%	15%	15%	15%	15%	15%	15%	15%	Environment Canada (2012)
F5	Other item ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	Environment Canada (2012)
ED	Exposure Duration	%Presence	100%	100%	100%	100%	100%	100%	100%	100%	Environment Canada (2012)
EPCdiet	Weighted Dietary	mg/kg dw food	1.833	187.686	9.481	14.606	46.138	0.485	0.448	1.247	
Ddiet	Dose dietary	mg/kgBW-day	0.128	13.138	0.664	1.022	3.230	0.034	0.031	0.087	
Dwater	Dose water	mg/kgBW-day	0.000	0.310	0.004	0.017	0.076	0.000	0.002	0.000	
Dtotal	Dose all	mg/kgBW-day	0.128	13.448	0.668	1.039	3.306	0.034	0.033	0.087	
Adj	Site Use Adjustment	fraction	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
EDI	Dose all - adjusted	mg/kgBW-day	0.13	13.45	0.67	1.04	3.31	0.03	0.03	0.09	
TRV	RMC-ESG Table IV-28	mg/kg-day	1.04	2.40	5.60	4.70	75.40	0.06	0.05	51.80	
TRV lower	Golder 2012	mg/kg-day		46					0.08		
TRV upper	Golder 2012	mg/kg-day		280					0.11		
HQ	Hazard Quotient	Unitless	0.123	5.60	0.119	0.22	0.04	0.58	0.63	0.0017	
HQ	HQ (Golder Lower TRV)	Unitless	-	0.29	-	-	-	-	0.41	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.05	-	-	-	-	0.32	-	

Table B-6b: Muskrat Food Web Model Using Inputs from Management Unit PC-E

Dose Based on Dry Weight Approximations

			As	Cr	Cu	Pb	Zn	Sb	PCB	TotalPAH	Notes
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	6.8	1227	47.3	143	184	4.1	0.4	12.2	90th percentile of IDW smoothed data for PC-E
EPCsed	Sediment Concentration	mg/kg ww	1.4	245	9.5	29	37	0.82	0.07	2.4	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.07	1.01	3.17	0.93	89	0.04	1.12	0.005	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.01	0.20	0.63	0.19	17.8	0.01	0.22	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	1.7	82	7.8	7.4	33	0.43	0.51	0.002	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0.306	14.7	1.404	1.332	5.94	0.0774	0.09	0.000	Calculated (assumed equal to macrophyte concentrations where no invertebrate estimates available)
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	
BW	Body weight	kg	1	1	1	1	1	1	1	1	Banfield 1974; Nagorsen 2005
FIR	Food ingestion-wet	kg ww food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-wet	kg ww food/day	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/kgBW-day	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	Campbell and MacArthur 1996
FIR	Food ingestion-dry	kg dw food/day	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	
WIR	Water ingestion	L/kgBW/day	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	Allometric equation from EPA 1993
WIR	Water ingestion	L/day	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
F1	Sediment ingestion	%FIR dw	2%	2%	2%	2%	2%	2%	2%	2%	Environment Canada (2012)
F2	Fish ingestion	%FIR dw	5%	5%	5%	5%	5%	5%	5%	5%	Environment Canada (2012)
F3	Macrophyte ingestion	%FIR dw	80%	80%	80%	80%	80%	80%	80%	80%	Environment Canada (2012)
F4	Invertebrate ingestion	%FIR dw	15%	15%	15%	15%	15%	15%	15%	15%	Environment Canada (2012)
F5	Other item ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	Environment Canada (2012)
ED	Exposure Duration	%Presence	100%	100%	100%	100%	100%	100%	100%	100%	Environment Canada (2012)
EPCdiet	Weighted Dietary	mg/kg dw food	1.754	56.879	8.515	9.928	39.482	0.492	0.139	0.788	
Ddiet	Dose dietary	mg/kgBW-day	0.123	3.982	0.596	0.695	2.764	0.034	0.010	0.055	
Dwater	Dose water	mg/kgBW-day	0.000	0.310	0.004	0.017	0.076	0.000	0.002	0.000	
Dtotal	Dose all	mg/kgBW-day	0.123	4.292	0.600	0.712	2.840	0.034	0.012	0.055	
Adj	Site Use Adjustment	fraction	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
EDI	Dose all - adjusted	mg/kgBW-day	0.12	4.29	0.60	0.71	2.84	0.03	0.01	0.06	
TRV	RMC-ESG Table IV-28	mg/kg-day	1.04	2.40	5.60	4.70	75.40	0.06	0.05	51.80	
TRV lower	Golder 2012	mg/kg-day		46.0					0.08		
TRV upper	Golder 2012	mg/kg-day		280.0					0.11		
HQ	Hazard Quotient	Unitless	0.118	1.79	0.107	0.15	0.04	0.58	0.22	0.0011	
HQ	HQ (Golder Lower TRV)	Unitless	-	0.09	-	-	-	-	0.14	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.02	-	-	-	-	0.11	-	

Table B-6c: Muskrat Food Web Model Using Inputs from Management Unit TC-OM

Dose Based on Dry Weight Approximations

			As	Cr	Cu	Pb	Zn	Sb	PCB	TotalPAH	Notes
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	16.3	1655	47.0	172	190	4.8	0.3	8.5	90th percentile of IDW smoothed data for TC-OM
EPCsed	Sediment Concentration	mg/kg ww	3.3	331	9.4	34	38	0.97	0.06	1.7	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.18	1.36	3.15	1.12	92	0.05	0.93	0.003	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.04	0.27	0.63	0.22	18.3	0.01	0.19	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	1.7	111	7.8	7.4	33	0.43	0.42	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0.306	19.9	1.404	1.332	5.94	0.0774	0.08	0.000	Calculated (assumed equal to macrophyte concentrations where no invertebrate estimates available)
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	
BW	Body weight	kg	1	1	1	1	1	1	1	1	Banfield 1974; Nagorsen 2005
FIR	Food ingestion-wet	kg ww food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-wet	kg ww food/day	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/kgBW-day	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	Campbell and MacArthur 1996
FIR	Food ingestion-dry	kg dw food/day	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	
WIR	Water ingestion	L/kgBW/day	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	Allometric equation from EPA 1993
WIR	Water ingestion	L/day	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
F1	Sediment ingestion	%FIR dw	2%	2%	2%	2%	2%	2%	2%	2%	Environment Canada (2012)
F2	Fish ingestion	%FIR dw	5%	5%	5%	5%	5%	5%	5%	5%	Environment Canada (2012)
F3	Macrophyte ingestion	%FIR dw	80%	80%	80%	80%	80%	80%	80%	80%	Environment Canada (2012)
F4	Invertebrate ingestion	%FIR dw	15%	15%	15%	15%	15%	15%	15%	15%	Environment Canada (2012)
F5	Other item ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	Environment Canada (2012)
ED	Exposure Duration	%Presence	100%	100%	100%	100%	100%	100%	100%	100%	Environment Canada (2012)
EPCdiet	Weighted Dietary	mg/kg dw food	1.950	69.750	8.507	10.527	39.733	0.508	0.115	0.715	
Ddiet	Dose dietary	mg/kgBW-day	0.136	4.882	0.596	0.737	2.781	0.036	0.008	0.050	
Dwater	Dose water	mg/kgBW-day	0.000	0.310	0.004	0.017	0.076	0.000	0.002	0.000	
Dtotal	Dose all	mg/kgBW-day	0.136	5.192	0.600	0.754	2.857	0.036	0.010	0.050	
Adj	Site Use Adjustment	fraction	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
EDI	Dose all - adjusted	mg/kgBW-day	0.14	5.19	0.60	0.75	2.86	0.04	0.01	0.05	
TRV	RMC-ESG Table IV-28	mg/kg-day	1.04	2.40	5.60	4.70	75.40	0.06	0.05	51.80	
TRV lower	Golder 2012	mg/kg-day		46.0					0.08		
TRV upper	Golder 2012	mg/kg-day		280.0					0.11		
HQ	Hazard Quotient	Unitless	0.131	2.16	0.107	0.16	0.04	0.60	0.19	0.0010	
HQ	HQ (Golder Lower TRV)	Unitless	-	0.11	-	-	-	-	0.12	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.02	-	-	-	-	0.09	-	

Table B-7a: Marsh Wren Food Web Model Using Inputs from Management Unit PC-W

Dose Based on Dry Weight Approximations

			As	Cr	Cu	Pb	Zn	Sb	PCB	TotalPAH	Notes
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	12.3	5595	95.4	380	350	4.2	1.1	35.8	90th percentile of IDW smoothed data for PC-W
EPCsed	Sediment Concentration	mg/kg ww	2.5	1119	19.1	76	70	0.83	0.23	7.2	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.14	4.60	6.39	2.47	169	0.04	3.61	0.014	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.03	0.92	1.28	0.49	33.8	0.01	0.72	0.003	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	*1.7*	374	*7.8*	*7.4*	*33*	*0.43*	1.63	0.005	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	*0.306*	67.3	*1.404*	*1.332*	*5.94*	*0.0774*	0.29	0.001	Calculated (assumed equal to macrophyte concentrations where no invertebrate estimates available)
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	
BW	Body weight	kg	0.01125	0.01125	0.01125	0.01125	0.01125	0.01125	0.01125	0.01125	EPA (1993) - average of male and female
FIR	Food ingestion-wet	kg ww food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-wet	kg ww food/day	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/kgBW-day	0.1755	0.1755	0.1755	0.1755	0.1755	0.1755	0.1755	0.1755	EPA (1993) adjusted to dry weight
FIR	Food ingestion-dry	kg dw food/day	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	Calculated
WIR	Water ingestion	L/kgBW/day	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	EPA (1993) - average of male and female
WIR	Water ingestion	L/day	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	Calculated
F1	Sediment ingestion	%FIR dw	2%	2%	2%	2%	2%	2%	2%	2%	Assumed
F2	Fish ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	
F3	Macrophyte ingestion	%FIR dw	20%	20%	20%	20%	20%	20%	20%	20%	EPA (1993)
F4	Invertebrate ingestion	%FIR dw	78%	78%	78%	78%	78%	78%	78%	78%	EPA (1993)
F5	Other item ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	EPA (1993)
ED	Exposure Duration	%Presence	100%	100%	100%	100%	100%	100%	100%	100%	EPA (1993)
EPCdiet	Weighted Dietary	mg/kg dw food	1.91	408.38	9.55	14.85	39.34	0.50	1.29	0.86	
Ddiet	Dose dietary	mg/kgBW-day	0.335	71.670	1.676	2.607	6.904	0.089	0.227	0.150	
Dwater	Dose water	mg/kgBW-day	0.000	0.837	0.011	0.046	0.205	0.000	0.005	0.000	
Dtotal	Dose all	mg/kgBW-day	0.335	72.507	1.687	2.653	7.109	0.089	0.232	0.150	
Adj	Site Use Adjustment	fraction	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
EDI	Dose all - adjusted	mg/kgBW-day	0.335	72.507	1.687	2.653	7.109	0.089	0.232	0.150	
TRV	RMC-ESG Table IV-28	mg/kg-day	2.24	2.66	4.05	1.63	66.1	NA	0.18	1.7	
TRV lower	Golder 2012	mg/kg-day		5					0.26		
TRV upper	Golder 2012	mg/kg-day		100					1.8		
HQ	Hazard Quotient	Unitless	0.150	27.3	0.417	1.63	0.11	NA	1.29	0.0883	
HQ	HQ (Golder Lower TRV)	Unitless	-	14.5	-	-	-	-	0.89	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.7	-	-	-	-	0.13	-	

Table B-7b: Marsh Wren Food Web Model Using Inputs from Management Unit PC-E

Dose Based on Dry Weight Approximations

			As	Cr	Cu	Pb	Zn	Sb	PCB	TotalPAH	Notes
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	6.8	1227	47.3	143	184	4.1	0.4	12.2	90th percentile of IDW smoothed data for PC-E
EPCsed	Sediment Concentration	mg/kg ww	1.4	245	9.5	29	37	0.8	0.1	2.4	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.075	1.01	3.17	0.93	88.97	0.039	1.12	0.005	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.015	0.20	0.63	0.19	17.8	0.008	0.22	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	1.7	82	7.8	7.4	33	0.43	0.51	0.002	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0.306	15	1.404	1.332	5.94	0.0774	0.09	0.000	Calculated (assumed equal to macrophyte concentrations where no invertebrate estimates available)
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	
BW	Body weight	kg	0.01125	0.01125	0.01125	0.01125	0.01125	0.01125	0.01125	0.01125	EPA (1993) - average of male and female
FIR	Food ingestion-wet	kg ww food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-wet	kg ww food/day	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/kgBW-day	0.1755	0.1755	0.1755	0.1755	0.1755	0.1755	0.1755	0.1755	EPA (1993) adjusted to dry weight
FIR	Food ingestion-dry	kg dw food/day	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	Calculated
WIR	Water ingestion	L/kgBW/day	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	EPA (1993) - average of male and female
WIR	Water ingestion	L/day	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	Calculated
F1	Sediment ingestion	%FIR dw	2%	2%	2%	2%	2%	2%	2%	2%	Assumed
F2	Fish ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	
F3	Macrophyte ingestion	%FIR dw	20%	20%	20%	20%	20%	20%	20%	20%	EPA (1993)
F4	Invertebrate ingestion	%FIR dw	78%	78%	78%	78%	78%	78%	78%	78%	EPA (1993)
F5	Other item ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	EPA (1993)
ED	Exposure Duration	%Presence	100%	100%	100%	100%	100%	100%	100%	100%	EPA (1993)
EPCdiet	Weighted Dietary	mg/kg dw food	1.80	93.45	8.59	10.10	36.02	0.50	0.40	0.38	
Ddiet	Dose dietary	mg/kgBW-day	0.316	16.401	1.508	1.773	6.322	0.088	0.071	0.067	
Dwater	Dose water	mg/kgBW-day	0.000	0.837	0.011	0.046	0.205	0.000	0.005	0.000	
Dtotal	Dose all	mg/kgBW-day	0.316	17.238	1.518	1.819	6.527	0.088	0.076	0.067	
Adj	Site Use Adjustment	fraction	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
EDI	Dose all - adjusted	mg/kgBW-day	0.316	17.238	1.518	1.819	6.527	0.088	0.076	0.067	
TRV	RMC-ESG Table IV-28	mg/kg-day	2.24	2.66	4.05	1.63	66.1	NA	0.18	1.7	
TRV lower	Golder 2012	mg/kg-day		5					0.26		
TRV upper	Golder 2012	mg/kg-day		100					1.8		
HQ	Hazard Quotient	Unitless	0.141	6.5	0.375	1.12	0.10	NA	0.42	0.0394	
HQ	HQ (Golder Lower TRV)	Unitless	-	3.4	-	-	-	-	0.29	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.2	-	-	-	-	0.04	-	

Table B-7c: Marsh Wren Food Web Model Using Inputs from Management Unit TC-OM

Dose Based on Dry Weight Approximations

			As	Cr	Cu	Pb	Zn	Sb	PCB	TotalPAH	Notes
Msed	Moisture (sed)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mfish	Moisture (fish)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Mmacro	Moisture (macrophyte)	fraction	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Minvert	Moisture (invertebrate)	fraction	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	
Mother	Moisture (other)	fraction	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	
EPCw	Water Concentration	mg/L	0	3.1	0.04	0.17	0.76	0	0.019	0.0003	
EPCsed	Sediment Concentration	mg/kg dw	16.3	1655	47.0	172	190	4.8	0.3	8.5	90th percentile of IDW smoothed data for TC-OM
EPCsed	Sediment Concentration	mg/kg ww	3.3	331	9.4	34	38	1.0	0.1	1.7	Calculated
EPCfish	Fish Concentration	mg/kg dw	0.180	1.36	3.15	1.12	91.72	0.046	0.93	0.003	Calculated
EPCfish	Fish Concentration	mg/kg ww	0.036	0.27	0.63	0.22	18.3	0.009	0.19	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCmacro	Macrophyte Concentration	mg/kg dw	1.7	25	7.8	7.4	33	0.43	0	0.68	Retained RMC estimates
EPCmacro	Macrophyte Concentration	mg/kg ww	0.17	2.5	0.78	0.74	3.3	0.043	0	0.068	Calculated
EPCinv	Invertebrate Concentration	mg/kg dw	1.7	111	7.8	7.4	33	0.43	0.42	0.001	Prorated RMC estimates (multiplied by ratio of respective sediment EPCs)
EPCinv	Invertebrate Concentration	mg/kg ww	0.306	20	1.404	1.332	5.94	0.0774	0.08	0.000	Calculated (assumed equal to macrophyte concentrations where no invertebrate estimates available)
EPCother	Other Item Conc.	mg/kg dw	0	0	0	0	0	0	0	0	
EPCother	Other Item Conc.	mg/kg ww	0	0	0	0	0	0	0	0	
BW	Body weight	kg	0.01125	0.01125	0.01125	0.01125	0.01125	0.01125	0.01125	0.01125	EPA (1993) - average of male and female
FIR	Food ingestion-wet	kg ww food/kgBW-day	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-wet	kg ww food/day	NA	NA	NA	NA	NA	NA	NA	NA	
FIR	Food ingestion-dry	kg dw food/kgBW-day	0.1755	0.1755	0.1755	0.1755	0.1755	0.1755	0.1755	0.1755	EPA (1993) adjusted to dry weight
FIR	Food ingestion-dry	kg dw food/day	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	Calculated
WIR	Water ingestion	L/kgBW/day	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	EPA (1993) - average of male and female
WIR	Water ingestion	L/day	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	Calculated
F1	Sediment ingestion	%FIR dw	2%	2%	2%	2%	2%	2%	2%	2%	Assumed
F2	Fish ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	
F3	Macrophyte ingestion	%FIR dw	20%	20%	20%	20%	20%	20%	20%	20%	EPA (1993)
F4	Invertebrate ingestion	%FIR dw	78%	78%	78%	78%	78%	78%	78%	78%	EPA (1993)
F5	Other item ingestion	%FIR dw	0%	0%	0%	0%	0%	0%	0%	0%	
Fsite	Proportion site use	%Site Use	100%	100%	100%	100%	100%	100%	100%	100%	EPA (1993)
ED	Exposure Duration	%Presence	100%	100%	100%	100%	100%	100%	100%	100%	EPA (1993)
EPCdiet	Weighted Dietary	mg/kg dw food	1.99	124.32	8.58	10.69	36.14	0.52	0.33	0.31	
Ddiet	Dose dietary	mg/kgBW-day	0.350	21.818	1.506	1.877	6.342	0.091	0.058	0.054	
Dwater	Dose water	mg/kgBW-day	0.000	0.837	0.011	0.046	0.205	0.000	0.005	0.000	
Dtotal	Dose all	mg/kgBW-day	0.350	22.655	1.517	1.922	6.547	0.091	0.064	0.054	
Adj	Site Use Adjustment	fraction	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
EDI	Dose all - adjusted	mg/kgBW-day	0.350	22.655	1.517	1.922	6.547	0.091	0.064	0.054	
TRV	RMC-ESG Table IV-28	mg/kg-day	2.24	2.66	4.05	1.63	66.1	NA	0.18	1.7	
TRV lower	Golder 2012	mg/kg-day		5					0.26		
TRV upper	Golder 2012	mg/kg-day		100					1.8		
HQ	Hazard Quotient	Unitless	0.156	8.5	0.375	1.18	0.10	NA	0.35	0.0318	
HQ	HQ (Golder Lower TRV)	Unitless	-	4.5	-	-	-	-	0.24	-	
HQ	HQ (Golder Upper TRV)	Unitless	-	0.2	-	-	-	-	0.04	-	

Table B-8: Summary of Ecological Risks for Wildlife Receptors, Calculated Using Revised Food Web Model

Individual Management Units	Area (ha)	Mink			Muskrat			Mallard			Marsh Wren			Heron			Osprey		
		PCB	Cr	Other	PCB	Cr	Other	PCB	Cr	Other	PCB	Cr	Other	PCB	Cr	Other	PCB	Cr	Other
PC-E	9.5	<1.0	<1.0	<1.0	<1.0	1.8	<1.0	<1.0	1.0	<1.0		3.4	1.1						
PC-W	7.3	1.2	<1.0	<1.0	<1.0	5.6	<1.0	<1.0	2.2	<1.0	1.3	14.5	1.6						
TC-OM	2.6				<1.0	2.2	<1.0					4.5	1.2						
TC-RC	3.6	-	-	-	-	-	-	<1.0	1.0	<1.0	-	-	-						
TC-1	26.1	-	-	-	-	-	-				-	-	-						
WM	1.9	-	-	-	-	-	-				-	-	-						
TC-2A	5.1	-	-	-	-	-	-	<1.0	<1.0	<1.0	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
TC-2B	8.2	-	-	-	-	-	-				-	-	-						
TC-3A	4.1	-	-	-	-	-	-				-	-	-						
TC-3B	3.1	-	-	-	-	-	-	<1.0	<1.0	<1.0	-	-	-						
TC-4	4.2	-	-	-	-	-	-				-	-	-						
TC-5	9.2	-	-	-	-	-	-	<1.0	<1.0	<1.0	-	-	-						
TC-AB	4.4	-	-	-	-	-	-				-	-	-						

Negligible Risk	(dark green)	All HQ values below 1.0 using screening level TRVs
Low Risk	(light green)	HQ values above 1.0 but only using Eco-SSL screening TRV (exceedance of Eco-SSL shown as value in cell)
Moderate Risk	(yellow)	HQ values below 1.0 using Golder (2012) lower-bound TRV (exceedance of lower-bound TRV shown as value in cell)
High Risk	(orange)	HQ values below 1.0 using Golder (2012) upper-bound TRV
Not Applicable	-	Suitable habitat for receptor not present within management area (no HQs calculated)

APPENDIX C

Human Health Risk Model

Table 1: Sediment Screening
Human Health Risk Refinement
Kingston Inner Harbour

Parameter	Units	CCME Soil Quality Guidelines[1]		Ontario S1 Risk Components - Soil Contact[2]	Ontario Background Sediment Standards[3]	US EPA Regional Soil Screening Levels[4]	REFERENCE AREA (PC-N)		NORTH EXPOSURE AREA OF WESTERN KIH		CENTRAL EXPOSURE AREA OF WESTERN KIH		SOUTH EXPOSURE AREA OF WESTERN KIH	
		Guideline	Notes				Maximum Concentration[5]	95th Percentile Concentration	Maximum Measured Concentration	95% UCLM (based on IDW data)	Maximum Measured Concentration	95% UCLM (based on IDW data)	Maximum Measured Concentration	95% UCLM (based on IDW data)
Metals														
Aluminum	mg/kg	-	-	-	-	**15,400**	**24,700**	**22,420**	**30,900**	**16,358**	**35,900**	**22,321**	**20,000**	15,037
Antimony	mg/kg	20	G	**7.5**	-	-	0.40	NA	**16.9**	2.4	**22.9**	4.8	**10**	1.3
Arsenic	mg/kg	**12**	SI	0.95	6	-	4.0	3.2	**13**	6.3	**742**	**67.5**	**32**	11.4
Barium	mg/kg	**6800**	DC	3800	-	-	235	228	338	NA	334	NA	440	NA
Beryllium	mg/kg	**75**	DC	38	-	-	0.6 (<4)	4	1.35 (<4.0)	NA	1.68	NA	0.75	NA
Boron	mg/kg	-	-	**4300**	-	-	36.8 (<40)	40	30.1	NA	-	NA	11	NA
Cadmium	mg/kg	**14**	SI	0.69	0.6	-	1.5	1.2	3	NA	3	NA	1.2	NA
Calcium	mg/kg	-	-	-	-	-	25,000	23,955	130,000	NA	73,500	NA	120,000	NA
Chromium	mg/kg	**220**	SI	28,000	26	-	**240**	191	**9900**	**1835**	**1140**	**827.5**	**940**	**444.5**
Cobalt	mg/kg	50	G	22	**50**	-	16.0	15.5	19.2	12.2	**110**	34.5	21	13.5
Copper	mg/kg	**1100**	SI	600	16	-	36.0	34.6	180	NA	337	NA	780	NA
Iron	mg/kg	-	-	-	-	**11,000**	**30,800**	**30,620**	**37,700**	**25,332**	**37,700**	**31,523**	**32,000**	**25,898**
Lead	mg/kg	**140**	SI	-	31	-	72.0	70.2	**490**	**159**	**840**	**193**	**510**	**151**
Magnesium	mg/kg	-	-	-	-	-	11,500	10,565	18,600	NA	22,900	NA	17,000	NA
Manganese	mg/kg	-	-	-	-	**360**	**890**	**886**	**849**	**540**	**1840**	**852**	**1100**	**676**
Mercury	mg/kg	**6.6**	SI	**9.8 (2 for MeHg)**	0.2	-	0.33	0.29	0.675	0.29	**8.5**	1.43	1.9	0.75
Molybdenum	mg/kg	10	G	**110**	-	-	0.7 (<2.0)	2.0	3.1	NA	2	NA	2.3	NA
Nickel	mg/kg	50	G	**330**	16	-	28.3	27.3	38	NA	322	NA	34	NA
Phosphorus	mg/kg	-	-	-	-	-	1000	973	2300	NA	1470	NA	1600	NA
Potassium	mg/kg	-	-	-	-	-	5910	5278	9260	NA	10,700	NA	3900	NA
Selenium	mg/kg	**80**	DC	110	-	-	2.8 (<10)	10	2 (<10)	NA	2	NA	1.9	NA
Silver	mg/kg	20	G	**77**	0.5	-	0.2 (<0.5)	0.5	1.9	NA	9	NA	4.3	NA
Sodium	mg/kg	-	-	-	-	-	726	721	1110	NA	1490	NA	1700	NA
Strontium	mg/kg	-	-	-	-	**9400**	227	218	756	NA	813	NA	680	NA
Sulphur	mg/kg	-	-	-	-	-	29,600	24,455	4600	NA	-	NA	-	NA
Thallium	mg/kg	**1**	SI, P	0.29	-	-	0.22 (<1.0)	1.0	0.497	NA	0.613	NA	0.38	NA
Tin	mg/kg	50	G	-	-	**9400**	2.4 (<5)	5	15	NA	90	NA	160	NA
Titanium	mg/kg	-	-	-	-	**28,000**	1610	1554	1750	NA	1400	NA	-	NA
Uranium	mg/kg	**23**	DC	23	-	-	0.96 (<10)	10	1.07 (<10)	NA	1.37	NA	0.98	NA
Vanadium	mg/kg	130	G	**39**	-	-	**48.9**	**48.5**	**67.7**	33.8	**67**	**55.5**	**48**	**39.2**
Zinc	mg/kg	200	G	**5600**	120	-	141	138	720	NA	442	NA	460	NA
Polychlorinated Biphenyls														
Aroclor 1242	mg/kg	-		-	-	-	<0.1	NA	0.012	NA	-	NA	0.08 (<0.10)	NA
Aroclor 1254	mg/kg	-		-	-	-	0.019 (<0.1)	NA	0.33	NA	0.83	NA	2.11	NA
Aroclor 1260	mg/kg	-		-	-	-	0.044 (<0.1)	0.074	2.1	NA	0.69	NA	0.42	NA
Total PCBs	mg/kg	1.3	G	**0.35**	0.07	-	0.10	0.072	**2.56**	0.327	**1.2**	**0.422**	**1.37**	**0.451**

Parameter	Units	CCME Soil Quality Guidelines[1]		Ontario S1 Risk Components - Soil Contact[2]	Ontario Background Sediment Standards[3]	US EPA Regional Soil Screening Levels[4]	REFERENCE AREA (PC-N)		NORTH EXPOSURE AREA OF WESTERN KIH		CENTRAL EXPOSURE AREA OF WESTERN KIH		SOUTH EXPOSURE AREA OF WESTERN KIH	
		Guideline	Notes				Maximum Concentration[5]	95th Percentile Concentration	Maximum Measured Concentration	95% UCLM (based on IDW data)	Maximum Measured Concentration	95% UCLM (based on IDW data)	Maximum Measured Concentration	95% UCLM (based on IDW data)
Polycyclic Aromatic Hydrocarbons														
Carcinogenic														
Benzo(a)anthracene	mg/kg	see B[a]P TPE	PEF=0.1	0.78	0.32	-	0.29	0.23	6.69	NA	5.1	NA	2.4	NA
Benzo(a)pyrene	mg/kg	see B[a]P TPE	PEF=1.0	0.078	0.37	-	0.33	0.28	11.4	NA	4.8	NA	3.8	NA
Benzo(b)fluoranthene	mg/kg	see B[a]P TPE	PEF=0.1	0.78	-	-	0.22	0.19	4.6	NA	5.9	NA	2.7	NA
Benzo(j)fluoranthene	mg/kg	see B[a]P TPE	PEF=0.1	-	-	-	0.26	NA	13.1	NA	5.92	NA	2.1	NA
Benzo(k)fluoranthene	mg/kg	see B[a]P TPE	PEF=0.1	0.78	0.24	-	0.24	0.20	1.6	NA	2.3	NA	1.3	NA
Benzo(ghi)perylene	mg/kg	see B[a]P TPE	PEF=0.01	7.8	0.17	-	0.27	0.22	6.55	NA	2.8	NA	2	NA
Chrysene	mg/kg	see B[a]P TPE	PEF=0.01	7.8	0.34	-	0.34	0.28	7.99	NA	5.1	NA	2.6	NA
Dibenz(a,h)anthracene	mg/kg	see B[a]P TPE	PEF=1.0	0.078	0.06	-	0.22	0.12	1.81	NA	0.84	NA	0.49	NA
Indeno(1,2,3-cd)pyrene	mg/kg	see B[a]P TPE	PEF=0.1	0.78	0.2	-	0.29	0.26	6.17	NA	3.1	NA	1.8	NA
B(a)P TPE	mg/kg	**5.3**	DC	-	-	-	0.66	0.49	**16.0**	3.9	**7.4**	2.1	**5.31**	1.2
Non-Carcinogenic														
Anthracene	mg/kg	-		**5400**	0.22	-	0.11	0.084	2.19	NA	1.9	NA	1.2	NA
Acenaphthene	mg/kg	-		**78**	-	-	0.017 (<0.05)	0.050	1.2	NA	0.86	NA	0.35	NA
Acenaphthylene	mg/kg	-		**7.8**	-	-	0.038 (<0.05)	0.050	2.45	NA	0.36	NA	0.75	NA
Fluoranthene	mg/kg	-		**7.8**	0.75	-	0.42	0.37	7.33	NA	7.66	NA	4.3	NA
Fluorene	mg/kg	-		**720**	0.19	-	0.038 (<0.05)	0.050	0.62	NA	1.2	NA	0.33	NA
1-Methylnaphthalene	mg/kg	-		**72**	-	-	0.053	NA	-	NA	-	NA	0.3	NA
2-Methylnaphthalene	mg/kg	-		**72**	-	-	0.067	NA	3.8	NA	-	NA	0.69	NA
Naphthalene	mg/kg	-		**360**	-	-	0.10	0.087	0.926	NA	1.2	NA	6.1	NA
Phenanthrene[6]	mg/kg	-		**78**	0.56	-	0.50	0.32	4.22	NA	6.34	NA	2.1	NA
Pyrene	mg/kg	-		**78**	0.49	-	0.44	0.42	9.79	NA	6.13	NA	4.5	NA
Perylene[7]	mg/kg	-		**78**	0.49	-	0.075	NA	1.6	NA	0.78	NA	0.61	NA
Pesticides & Herbicides														
Aldrin	mg/kg	-		**0.56**	0.002	-	<0.01	NA	-	NA	-	NA	<0.05	NA
alpha-BHC	mg/kg	-		-	-	**0.86**	<0.01	NA	-	NA	-	NA	<0.05	NA
beta-BHC	mg/kg	-		-	-	**3**	<0.01	NA	-	NA	-	NA	<0.05	NA
delta-BHC	mg/kg	-		-	-	-	<0.01	NA	-	NA	-	NA	<0.05	NA
a-Chlordane	mg/kg	-		-	-	-	<0.01	NA	-	NA	-	NA	<0.05	NA
g-Chlordane	mg/kg	-		-	-	-	<0.01	NA	-	NA	-	NA	<0.05	NA
Chlordane (Total)	mg/kg	-		**0.59**	0.007	-	<0.01	NA	-	NA	-	NA	<0.05	NA
o,p-DDD	mg/kg	-		**3.3**	0.008	-	<0.01	NA	-	NA	-	NA	<0.1	NA
p,p-DDD	mg/kg	-		**3.3**	0.008	-	<0.01	NA	-	NA	-	NA	<0.05	NA
o,p-DDD + p,p-DDD	mg/kg	-		**3.3**	0.008	-	<0.01	NA	-	NA	-	NA	<0.1	NA
o,p-DDE	mg/kg	-		**2.3**	0.005	-	<0.01	NA	-	NA	-	NA	<0.05	NA
p,p-DDE	mg/kg	-		**2.3**	0.005	-	<0.01	NA	-	NA	-	NA	<0.05	NA
o,p-DDE + p,p-DDE	mg/kg	-		**2.3**	0.005	-	<0.01	NA	-	NA	-	NA	<0.05	NA
o,p-DDT	mg/kg	-		**2.3**	0.007	-	<0.01	NA	-	NA	-	NA	<0.05	NA
p,p-DDT	mg/kg	-		**2.3**	0.007	-	<0.01	NA	-	NA	-	NA	<0.05	NA
o,p-DDT + p,p-DDT	mg/kg	-		**2.3**	0.007	-	<0.01	NA	-	NA	-	NA	<0.05	NA
DDT+ Metabolites	mg/kg	0.7	SQG-E	**2.3**	0.007	-	<0.01	NA	-	NA	-	NA	<0.1	NA
Dieldrin	mg/kg	-		**0.94**	0.002	-	<0.01	NA	-	NA	-	NA	<0.05	NA
Endosulfan I (alpha)	mg/kg	-		-	-	-	<0.01	NA	-	NA	-	NA	<0.05	NA
Endosulfan II	mg/kg	-		-	-	-	<0.01	NA	-	NA	-	NA	<0.05	NA
Endosulfan sulfate	mg/kg	-		-	-	-	<0.01	NA	-	NA	-	NA	<0.05	NA
Total Endosulfan	mg/kg	-		**38**	-	-	<0.01	NA	-	NA	-	NA	<0.05	NA
Endrin	mg/kg	-		**4.7**	0.003	-	<0.01	NA	-	NA	-	NA	<0.05	NA
Endrin aldehyde	mg/kg	-		-	-	-	<0.01	NA	-	NA	-	NA	<0.05	NA
Endrin ketone	mg/kg	-		-	-	-	<0.01	NA	-	NA	-	NA	<0.05	NA
Heptachlor	mg/kg	-		**0.15**	-	-	<0.01	NA	-	NA	-	NA	<0.05	NA

Table 1: Sediment Screening
Human Health Risk Refinement
Kingston Inner Harbour

Parameter	Units	CCME Soil Quality Guidelines(1)		Ontario S1 Risk Components - Soil Contact(2)	Ontario Background Sediment Standards(3)	US EPA Regional Soil Screening Levels(4)	REFERENCE AREA (PC-N)		NORTH EXPOSURE AREA OF WESTERN KIH		CENTRAL EXPOSURE AREA OF WESTERN KIH		SOUTH EXPOSURE AREA OF WESTERN KIH	
		Guideline	Notes				Maximum Concentration(5)	95th Percentile Concentration	Maximum Measured Concentration	95% UCLM (based on IDW data)	Maximum Measured Concentration	95% UCLM (based on IDW data)	Maximum Measured Concentration	95% UCLM (based on IDW data)
Heptachlor epoxide	mg/kg	-		0.11	0.005	-	<0.01	NA	-	NA	-	NA	<0.05	NA
Hexachlorobenzene	mg/kg	-		0.52	0.02	-	<0.01	NA	-	NA	-	NA	<0.05	NA
Lindane (gamma-hexachlorocyclohexane)	mg/kg	-		0.25	-	-	<0.01	NA	-	NA	-	NA	<0.05	NA
Methoxychlor	mg/kg	-		0.38	-	-	<0.03	NA	-	NA	-	NA	<0.2	NA
Mirex	mg/kg	-		-	-	0.36	<0.01	NA	-	NA	-	NA	<0.05	NA
Octachlorostyrene	mg/kg	-		-	-	-	<0.01	NA	-	NA	-	NA	<0.05	NA
Toxaphene	mg/kg	-		-	-	4.9	<0.5	NA	-	NA	-	NA	<2	NA
Oganic Tin Compounds														
Tributyl tin	mg/kg	-		-	-	3.8	-	-	-	NA	-	NA	0.21	NA

Notes:

< = below laboratory detection limit; "-" = no value or not applicable; % = percent; B(a)P TPE = benzo(a)pyrene total potency equivalents; BHC = hexachlorocyclohexane; COPC = contaminant of potential concern; DC = direct contact; DDD = dichlorodiphenyldichloroethane; DDE = dichlorodiphenyldichloroethylene; DDT = dichlorodiphenyltrichloroethane; G = generic; IDW = inverse distance weighted; KIH = Kingston Inner Harbour; MeHg = methylmercury; mg/kg = milligram per kilogram; NA = not applicable, a 95% UCLM was not calculated if the maximum concentration did not exceed the selected screening criterion; PCB = polychlorinated biphenyl; PEF = potency equivalency factor; SI = soil ingestion; SQG-E = soil quality guideline-environmental; UCLM = upper confidence limit of the mean.

1 - CCME 1999, including updates to 2015; Soil quality guidelines for residential/parkland land use
2 - OMOE 2011a; Soil components for Table 3 - Full depth, non-potable water scenario for a residential/parkland land use and coarse textured soil.
3 - OMOE 2011b; Table 1 - Full depth background site condition standards for sediment and all types of property use
4 - US EPA 2015; Residential soil RSLs were only presented if values were not available from CCME or OMOE. RSLs were corrected to reflect a hazard quotient of 0.2 (divided by 5 for non-carcinogens) and an incremental lifetime cancer risk of 1x10-5 (multiplied by 10 for carcinogens).
5 - The maximum detection limit is provided in brackets if it is greater than the measured concentration.
6 - Pyrene used as a surrogate for phenanthrene for screening purposes, as considered by VDEQ (2014) for risk-based screening levels.
7 - Pyrene was used as a surrogate for perylene for screening purposes, in the absence of a guideline or standard for perylene.

value	= Selected sediment criterion
value	= Exceeds selected sediment criterion

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Table 2: Surface Water Screening
Human Health Risk Refinement
Kingston Inner Harbour

Parameter	Units	Health Canada Drinking Water Guidelines[1]	Ontario Drinking Water Standards[2]	US EPA Regional Screening Levels Residential Tapwater[3]	Selected Health Based Drinking Water Criterion x 10[4]	Maximum Measured Concentration
Total Metals						
Antimony	mg/L	0.006	-	-	0.06	<0.01
Arsenic	mg/L	0.01	0.025	-	0.1	<0.003
Chromium	mg/L	0.05	0.05	-	0.5	**22**
Copper	mg/L	1 [AO]	1 [AO]	0.16	1.6	0.21
Lead	mg/L	0.01	0.01	-	0.1	**1.1**
Zinc	mg/L	5 [AO]	5 [AO]	1.2	12	5.3
Dissolved Metals						
Antimony	mg/L	-	-	-	-	-
Arsenic	mg/L	-	-	-	-	<0.003
Chromium	mg/L	-	-	-	-	<0.005
Copper	mg/L	-	-	-	-	0.0064
Lead	mg/L	-	-	-	-	<0.010
Zinc	mg/L	-	-	-	-	1.9
Polycyclic Aromatic Hydrocarbons						
Acenaphthene	mg/L	-	-	0.106	1.06	<0.001
Acenaphthylene	mg/L	-	-	-	-	<0.001
Anthracene	mg/L	-	-	0.36	3.6	<0.00001[a]
Benzo(a)anthracene	mg/L	-	-	0.00012	0.0012	0.000022
Benzo(a)pyrene	mg/L	0.00001	0.00001	-	-	<0.000001[a]
Benzo(b)fluoranthene	mg/L	-	-	0.00034	0.0034	<0.00001[a]
Benzo(e)pyrene	mg/L	-	-	-	-	<0.00001
Benzo(ghi)perylene	mg/L	-	-	-	-	<0.00002[a]
Benzo(k)fluoranthene	mg/L	-	-	0.0034	0.034	<0.00001[a]
Chrysene	mg/L	-	-	0.034	0.34	0.000031
Dibenz(a,h)anthracene	mg/L	-	-	0.000034	0.00034	<0.00002[a]
7,12-Dimethylbenz(a)anthracene	mg/L	-	-	0.000001	0.00001	<0.00001[a]
Fluoranthene	mg/L	-	-	0.16	1.6	0.000081
Fluorene	mg/L	-	-	0.058	0.58	<0.001
Indeno(1,2,3-cd)pyrene	mg/L	-	-	0.00034	0.0034	<0.00002[a]
Naphthalene	mg/L	-	-	0.00122	0.0122	<0.002
Perylene[5]	mg/L	-	-	0.024	0.24	<0.00001
Phenanthrene[6]	mg/L	-	-	0.024	0.24	0 (<0.001)
Pyrene	mg/L	-	-	0.024	0.24	0.000078 (<0.001)
Total PAH	mg/L	-	-	-	-	0.00043 (<0.01)
Polychlorinated Biphenyls						
Aroclor 1254	mg/L	-	-	-	-	<0.00002
Aroclor 1260	mg/L	-	-	-	-	<0.00002
Total PCBs	mg/L	-	0.003	-	0.03	0.00009

Notes:

"-" = no value or not applicable; < = below laboratory detection limit; AO = aesthetic objective; mg/L = milligram per litre; PAH = polycyclic aromatic hydrocarbon; PCBs = polychlorinated biphenyls.

1 - Health Canada 2014

2 - OMOE 2001

3 - US EPA 2015

US EPA RSLs were only presented if values were not available from Health Canada or OMOE. US EPA RSLs were corrected to reflect a hazard quotient of 0.2 (divided by 5 for non-carcinogens) and an incremental lifetime cancer risk of 10-5 (multiplied by 10 for carcinogens).

4 - The selected health-based potable water guidelines were adjusted by a factor of 10 to reflect an incidental ingestion rate that is 10 times lower than the intake of potable drinking water, as per guidance from the World Health Organization (WHO 2003). See Section 7.2.2.

5 - Pyrene was used as a surrogate for perylene for screening purposes, in the absence of a guideline or standard for perylene.

6 - Pyrene used as a surrogate for phenanthrene for screening purposes, as considered by VDEQ (2014) for risk-based screening levels.

a - Parameter had more than one detection limit. Where concentrations were all non-detect, the detection limits from the more recent data set were used as to screen the data.

value = Exceeds selected health based drinking water criterion

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APPENDIX C
Table 3: Fish Tissue Screening
Human Health Risk Refinement
Kingston Inner Harbour

Parameter	Units	US EPA Risk-Based Screening Levels for Fish Ingestion[1] Non-Cancer HQ=0.2	US EPA Risk-Based Screening Levels for Fish Ingestion[1] Cancer ILCR=1.0E-05	Maximum Measured Concentration[2]
Arsenic	mg/kg ww	0.0132	0.00231	*<0.010* [a]
Arsenic as DMA	mg/kg ww	-	-	<0.010
Arsenic as As(III)	mg/kg ww	-	-	<0.010
Arsenic as MMA	mg/kg ww	-	-	<0.010
Arsenic as As(V)	mg/kg ww	-	-	<0.010
Chromium as Cr(VI)	mg/kg ww	0.132	-	*<0.20*
Copper	mg/kg ww	4.0	-	0.21
Lead	mg/kg ww	0.0264	-	**0.41**
Mercury	mg/kg ww	0.013	-	**0.5**
Methylmercury	mg/kg ww	0.0088	-	**0.5**
Nickel	mg/kg ww	0.48[b]	-	0.2
Zinc	mg/kg ww	13.2	-	6.4
Aroclor 1242	mg/kg ww	-	-	<0.03
Aroclor 1254	mg/kg ww	-	-	0.04
Aroclor 1260	mg/kg ww	-	-	0.05
Total PCBs	mg/kg ww	0.00572	-	**1.4**

Notes:
< = below laboratory detection limit; DMA = dimethylarsinic acid; HQ = hazard quotient; ILCR = incremental lifetime cancer risk; mg/kg ww = milligram per kilogram wet weight; MMA = monomethylarsonous acid; PCB = polychlorinated biphenyl.
1 - US EPA Risk-Based Regional Screening Levels (RSLs) for Fish Ingestion (US EPA 2015)
The non-cancer RSLs were calculated using the RSL calculator (US EPA 2015) assuming a target hazard quotient of 0.2. Exposure parameters for the toddler were used, and daily consumption was conservatively assumed for screening purposes.
The cancer RSLs were calculated using the RSL calculator (US EPA 2015) assuming an incremental lifetime cancer risk of 1 in 100,000. Exposure parameters for the adult were used, and daily consumption was conservatively assumed for screening purposes.
2 - Includes fish fillet chemistry data available for the following species considered in the assessment: largemouth bass, northern pike, and perch.
a - The detection limit was not reported by RMC; therefore, the detection limit was assumed to be the same as that reported for organic arsenic compounds.
b - Nickel soluble salts
value = Detection limit exceeds screening value
value = Exceeds screening value

References
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APPENDIX C
Table 4: Exposure Concentrations
Human Health Risk Refinement
Kingston Inner Harbour

COPC	Western KIH Exposure Area	Exposure Concentration									
		Sediment[1]		Surface Water[2]				Fish[3]			
		Concentration (mg/kg)	Statistic	n	n det	Concentration (mg/L)	Statistic	n	n det	Concentration (mg/kg)	Statistic
Aluminum	North	16,358	95% UCLM[1]	-	-	No data		-	-	No data	
	Central	22,321	95% UCLM[1]	-	-	No data		-	-	No data	
	South	15,037	95% UCLM[1]	-	-	No data		-	-	No data	
Antimony	North	2.395	95% UCLM[1]	4	0	0.005	1/2 Detection Limit	-	-	No data	
	Central	4.833	95% UCLM[1]	3	0	0.005	1/2 Detection Limit	-	-	No data	
	South	1.322	95% UCLM[1]	1	0	0.005	1/2 Detection Limit	-	-	No data	
Arsenic	North	6.33	95% UCLM[1]	12	0	0.0015	1/2 Detection Limit			0.005	1/2 Detection Limit
	Central	67.51	95% UCLM[1]	5	0	0.0015	1/2 Detection Limit	8	0	0.005	1/2 Detection Limit
	South	11.44	95% UCLM[1]	1	0	0.0015	1/2 Detection Limit			0.005	1/2 Detection Limit
Chromium (sediment, water) Chromium VI (fish)	North	1835	95% UCLM[1]	20	18	3.565	95% UCLM			0.1	1/2 Detection Limit
	Central	827.5	95% UCLM[1]	9	7	0.0218	90th Percentile	8	0	0.1	1/2 Detection Limit
	South	444.5	95% UCLM[1]	3	2	0.001	Maximum			0.1	1/2 Detection Limit
Cobalt	North	NA[4]	-	-	-	No data		-	-	No data	
	Central	34.49	95% UCLM[1]	-	-	No data		-	-	No data	
	South	NA[4]	-	-	-	No data		-	-	No data	
Lead	North	158.8	95% UCLM[1]	20	15	0.202	95% UCLM			0.41	Maximum
	Central	193.1	95% UCLM[1]	9	6	0.00783	95% UCLM	5	2	0.41	Maximum
	South	151.1	95% UCLM[1]	3	2	0.00085	Maximum			0.41	Maximum
Manganese	North	539.6	95% UCLM[1]	-	-	No data		-	-	No data	
	Central	852.2	95% UCLM[1]	-	-	No data		-	-	No data	
	South	675.5	95% UCLM[1]	-	-	No data		-	-	No data	
Mercury (sediment) Methylmercury (fish)	North	0.286	95% UCLM[1]	-	-	No data				0.189	95% UCLM
	Central	1.432	95% UCLM[1]	-	-	No data		27	27	0.189	95% UCLM
	South	0.753	95% UCLM[1]	-	-	No data				0.189	95% UCLM
Vanadium	North	33.83	95% UCLM[1]	-	-	No data		-	-	No data	
	Central	55.51	95% UCLM[1]	-	-	No data		-	-	No data	
	South	39.19	95% UCLM[1]	-	-	No data		-	-	No data	
Total PCBs	North	0.327	95% UCLM[1]	8	8	0.00004925	95% UCLM			0.202	95% UCLM
	Central	0.422	95% UCLM[1]	4	4	0.0000082	90th Percentile	73	67	0.202	95% UCLM
	South	0.451	95% UCLM[1]	2	2	0.00001	Maximum			0.202	95% UCLM
Benzo(a)anthracene	North	0.646	95% UCLM[1]	12	1	0.00002	90th Percentile	-	-	No data	
	Central	1.399	95% UCLM[1]	7	0	0.00001	1/2 Detection Limit	-	-	No data	
	South	0.553	95% UCLM[1]	3	0	0.00001	1/2 Detection Limit	-	-	No data	
Benzo(a)pyrene	North	0.829	95% UCLM[1]	12	0	0.0000005	1/2 Detection Limit	-	-	No data	
	Central	1.441	95% UCLM[1]	7	0	0.0000005	1/2 Detection Limit	-	-	No data	
	South	0.614	95% UCLM[1]	3	0	0.0000005	1/2 Detection Limit	-	-	No data	
Benzo(b)fluoranthene	North	0.376	95% UCLM[1]	12	0	0.000005	1/2 Detection Limit	-	-	No data	
	Central	1.382	95% UCLM[1]	7	0	0.000005	1/2 Detection Limit	-	-	No data	
	South	0.665	95% UCLM[1]	3	0	0.000005	1/2 Detection Limit	-	-	No data	
Benzo(g,h,i)perylene	North	0.608	95% UCLM[1]	12	0	0.00001	1/2 Detection Limit	-	-	No data	
	Central	0.84	95% UCLM[1]	7	0	0.00001	1/2 Detection Limit	-	-	No data	
	South	0.417	95% UCLM[1]	3	0	0.00001	1/2 Detection Limit	-	-	No data	
Benzo(j)fluoranthene	North	1.808	95% UCLM[1]	-	-	No data		-	-	No data	
	Central	1.795	95% UCLM[1]	-	-	No data		-	-	No data	
	South	1.124	95% UCLM[1]	-	-	No data		-	-	No data	
Benzo(k)fluoranthene	North	0.437	95% UCLM[1]	12	0	0.000005	1/2 Detection Limit	-	-	No data	
	Central	0.645	95% UCLM[1]	7	0	0.000005	1/2 Detection Limit	-	-	No data	
	South	0.397	95% UCLM[1]	3	0	0.000005	1/2 Detection Limit	-	-	No data	
Chrysene	North	1.892	95% UCLM[1]	12	1	0.00001	90th Percentile	-	-	No data	
	Central	1.461	95% UCLM[1]	7	0	0.000005	1/2 Detection Limit	-	-	No data	
	South	0.526	95% UCLM[1]	3	0	0.000005	1/2 Detection Limit	-	-	No data	
Dibenzo(a,h)anthracene	North	0.198	95% UCLM[1]	12	0	0.00001	1/2 Detection Limit	-	-	No data	
	Central	0.233	95% UCLM[1]	7	0	0.00001	1/2 Detection Limit	-	-	No data	
	South	0.127	95% UCLM[1]	3	0	0.00001	1/2 Detection Limit	-	-	No data	
Indeno(1,2,3-c,d)pyrene	North	1.105	95% UCLM[1]	12	0	0.00001	1/2 Detection Limit	-	-	No data	
	Central	0.932	95% UCLM[1]	7	0	0.00001	1/2 Detection Limit	-	-	No data	
	South	0.465	95% UCLM[1]	3	0	0.00001	1/2 Detection Limit	-	-	No data	

Notes:

% = percent; COPC = contaminant of potential concern; DDT = dichlorodiphenyltrichloroethane; KIH = KIngston Inner Harbour; m = metre; mg/kg = milligram per kilogram; mg/L = milligram per litre; n = number of samples; n det = number of detected samples; NA = not applicable; PCBs = polychlorinated biphenyls; UCLM = upper confidence limit of the mean.

1 - For sediment, a 95% upper confidence limit of the mean (UCLM) was calculated using sediment chemistry data as described below.
- Spatial depictions of surface sediment (0 - 0.15 m) chemistry distributions (for 2003 to 2013 inclusive) were created using an ArcGIS Version 10.3.1 inverse-distance weighting (IDW) interpolation method.
- The IDW creates an estimation of the surface distribution of each chemical using multivariate interpolation of known concentrations of a scattered set of sampling locations.
- The IDW surface was then divided into 5 x 5 m grids and the interpolated concentration of each grid was used to the calculate the 95 percent upper confidence limit of the mean (95% UCLM) for each parameter within a study area.
- The 95% UCLMs were calculated using US EPA ProUCL software, version 5.0.

2 - For surface water, where sufficient data were available, 95% UCLMs were calculated using the US EPA's ProUCL software (US EPA 2013). Where a parameter was not detected in any of the samples (e.g., arsenic), half the detection limit was used as the exposure concentration (refer to Section 7.3.3.2). Where a parameter was detected and insufficient data were available to calculate a 95% UCLM, the 90th percentile (calculated using full detection limits) or maximum detected concentration was used as the exposure concentration.

3 - For fish, data from fillet of the following species were used to estimate exposure concentrations: yellow perch, largemouth bass and northern pike. Fish tissue data were pooled from the western half of KIH.

Where sufficient data were available, 95% UCLMs were calculated using the US EPA's ProUCL software (US EPA 2013).

Where a parameter was not detected, half the detection limit was used as the exposure concentration (see Section 7.3.3.3).

Five samples were analyzed for arsenic, which were all below the laboratory detection limit. However, the numerical detection limit was not reported by RMC (2014). For arsenic, the detection limit of these five samples was assumed to be the same as that reported for speciated arsenic (<0.010 mg/kg). As all reported values were non-detect, half the detection limit was used as the exposure concentration (see Section 7.3.3.3).

Total chromium was not analyzed in fish; therefore, the fish concentrations are for chromium VI (the species of chromium analyzed for (RMC 2014)).

Five samples were analyzed for lead, three of which were below the laboratory detection limit. However, the numerical detection limit was not reported by RMC (2014). For lead, the maximum detected concentration was used as the exposure concentration.

4 - Cobalt was not identified as a COPC in the north and south exposure areas of Western KIH.

Data sources

<u>Sediment</u>

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Tinney MD. 2006. Site investigation and ecological risk assessment of Kingston Inner Harbour (Master's Thesis). July 2006.

Benoit and Dove 2003; Golder 2010; and Malroz 2005; as cited in RMC 2014.

<u>Surface Water</u>

Royal Military College Environmental Sciences Group. 2014. Application of the Canada-Ontario decision-making framework for contaminated sediments in the Kingston Inner Harbour. February 2014.

<u>Fish</u>

Royal Military College Environmental Sciences Group. 2014. Application of the Canada-Ontario decision-making framework for contaminated sediments in the Kingston Inner Harbour. February 2014.

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References

US EPA (United States Environmental Protection Agency). 2013. ProUCL Software, Version 5.0.00. Available at: http://www2.epa.gov/land-research/proucl-software.

APPENDIX C

Table 5: Chemical Properties and Calculation of DA_{event} (Dermal Contact with Surface Water)

Human Health Risk Refinement

Kingston Inner Harbour

COPC[1]	Dermal Permeability Coefficient[2] [Kp] (cm/hour)	Event Duration [t_{event}] (hours/event)	COPC Concentration (mg//L)			Dermal Absorbed Dose [DAevent] ($mg/cm^2 \cdot event$)		
			Western KIH Exposure Area - North	Western KIH Exposure Area - Central	Western KIH Exposure Area - South	Western KIH Exposure Area - North	Western KIH Exposure Area - Central	Western KIH Exposure Area - South
Aluminum	0.001	1	No data	No data	No data	NA	NA	NA
Antimony	0.001	1	0.005	0.005	0.005	5.00E-09	5.00E-09	5.00E-09
Arsenic	0.001	1	0.0015	0.0015	0.0015	1.50E-09	1.50E-09	1.50E-09
Chromium	0.001	1	3.565	0.0218	0.001	3.57E-06	2.18E-08	1.00E-09
Cobalt	0.0004	1	No data	No data	No data	NA	NA	NA
Lead	0.0001	1	0.202	0.00783	0.00085	2.02E-08	7.83E-10	8.5E-11
Manganese	0.001	1	No data	No data	No data	NA	NA	NA
Mercury	0.001	1	No data	No data	No data	NA	NA	NA
Vanadium	0.001	1	No data	No data	No data	NA	NA	NA

Notes:

cm = centimetre; COPC = contaminant of potential concern; KIH = Kingston Inner Harbour; mg/cm^2 = milligram per square centimetre; mg/L = milligram per litre; NA = not applicable; RAFdermal = relative dermal absorption factor; RAForal = relative absorption factor from the gastrointestinal tract.

1 - Dermal contact with organic COPCs (i.e., high molecular weight PAHs and PCBs) was not considered a viable pathway. See Section7.2.2 of the report.

2 - Dermal permeability coefficients (Kp) were obtained from US EPA (2004).

References

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OMOE (Ontario Ministry of the Environment). 2011. Rationale for the development of soil and groundwater standards for use at contaminated sites in Ontario. April 2011. Standards Development Branch.

US EPA (United States Environmental Protection Agency). 2004. Risk assessment guidance for Superfund, Volume I: Human health evaluation manual (Part E, Supplemental guidance for dermal risk assessment), Final. July 2014. Office of Superfund Remediation and Technology Innovation. Washington, DC.

APPENDIX C
Table 6: Dose and Risk Estimates for the Toddler
Human Health Risk Refinement
Kingston Inner Harbour

TODDLER

Dose Estimates - Non-Carcinogenic

COPC	MEDIA	EXPOSURE DOSE												
		SEDIMENT						SURFACE WATER						FOOD (FISH)
	PATHWAY	INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO] (mg/kg BW/day)			DERMAL CONTACT WITH BEDDED SEDIMENTS (mg/kg BW/day)			INCIDENTAL INGESTION [DEEP WATER SCENARIO] (mg/kg BW/day)			DERMAL CONTACT (mg/kg BW/day)			FISH INGESTION (mg/kg BW/day)
	EXPOSURE AREA OF WESTERN KIH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	ALL
Aluminum		1.09E-03	1.49E-03	2.00E-03	3.40E-04	4.64E-04	6.25E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Antimony		1.60E-07	3.22E-07	1.76E-07	4.98E-07	1.00E-06	5.50E-07	2.16E-06	2.16E-06	4.33E-06	2.65E-07	2.65E-07	5.31E-07	N/A
Arsenic		4.22E-07	4.50E-06	1.53E-06	3.95E-07	4.21E-06	1.43E-06	6.49E-07	6.49E-07	1.30E-06	7.96E-08	7.96E-08	1.59E-07	3.25E-06
Chromium		1.22E-04	5.52E-05	5.93E-05	3.81E-04	1.72E-04	1.85E-04	1.54E-03	9.44E-06	8.66E-07	1.89E-04	1.16E-06	1.06E-07	6.49E-05
Cobalt		N/A	2.30E-06	N/A	N/A	7.17E-07	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lead		1.06E-05	1.29E-05	2.01E-05	1.98E-06	2.41E-06	3.77E-06	8.74E-05	3.39E-06	7.36E-07	1.07E-06	4.16E-08	9.02E-09	2.66E-04
Manganese		3.60E-05	5.68E-05	9.01E-05	1.12E-05	1.77E-05	2.81E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mercury		1.91E-08	9.55E-08	1.00E-07	5.94E-07	2.98E-06	3.13E-06	N/A	N/A	N/A	N/A	N/A	N/A	1.23E-04
Vanadium		2.26E-06	3.70E-06	5.23E-06	7.03E-06	1.15E-05	1.63E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total PCBs		2.18E-08	2.81E-08	6.01E-08	9.52E-08	1.23E-07	2.62E-07	2.13E-08	3.55E-09	8.66E-09	N/A	N/A	N/A	1.31E-04

Dose Estimates - Carcinogenic

COPC	MEDIA	EXPOSURE DOSE												
		SEDIMENT						SURFACE WATER						FOOD (FISH)
	PATHWAY	INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO]			DERMAL CONTACT WITH BEDDED SEDIMENTS			INCIDENTAL INGESTION [DEEP WATER SCENARIO]			DERMAL CONTACT			FISH INGESTION
	EXPOSURE AREA OF WESTERN KIH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	ALL
		(mg/kg BW/day)			(mg/kg BW/day)			(mg/kg BW/day)			(mg/kg BW/day)			(mg/kg BW/day)
Arsenic		7.76E-09	8.28E-08	2.81E-08	7.26E-09	7.74E-08	2.62E-08	1.19E-08	1.19E-08	2.39E-08	1.46E-09	1.46E-09	2.93E-09	1.83E-07
		Average Daily Dose												
PAHs		(mg/kg BW/day)			(μg/cm²/day)			(mg/kg BW/day)						
Benzo(a)anthracene		7.92E-10	1.72E-09	1.36E-09	2.01E-06	4.35E-06	3.44E-06	1.59E-10	7.96E-11	1.59E-10	N/A	N/A	N/A	N/A
Benzo(a)pyrene		1.02E-09	1.77E-09	1.51E-09	2.58E-06	4.48E-06	3.82E-06	3.98E-12	3.98E-12	7.96E-12	N/A	N/A	N/A	N/A
Benzo(b)fluoranthene		4.61E-10	1.69E-09	1.63E-09	1.17E-06	4.30E-06	4.14E-06	3.98E-11	3.98E-11	7.96E-11	N/A	N/A	N/A	N/A
Benzo(g,h,i)perylene		7.45E-10	1.03E-09	1.02E-09	1.89E-06	2.61E-06	2.60E-06	7.96E-11	7.96E-11	1.59E-10	N/A	N/A	N/A	N/A
Benzo(j)fluoranthene		2.22E-09	2.20E-09	2.76E-09	5.63E-06	5.59E-06	6.99E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(k)fluoranthene		5.36E-10	7.91E-10	9.73E-10	1.36E-06	2.01E-06	2.47E-06	3.98E-11	3.98E-11	7.96E-11	N/A	N/A	N/A	N/A
Chrysene		2.32E-09	1.79E-09	1.29E-09	5.89E-06	4.55E-06	3.27E-06	7.96E-11	3.98E-11	7.96E-11	N/A	N/A	N/A	N/A
Dibenzo(a,h)anthracene		2.43E-10	2.86E-10	3.11E-10	6.16E-07	7.25E-07	7.90E-07	7.96E-11	7.96E-11	1.59E-10	N/A	N/A	N/A	N/A
Indeno(1,2,3-c,d)pyrene		1.35E-09	1.14E-09	1.14E-09	3.44E-06	2.90E-06	2.89E-06	7.96E-11	7.96E-11	1.59E-10	N/A	N/A	N/A	N/A
		Average Daily Dose for Short-Term Exposures (Incorporating ADAF)												
PAHs		(mg/kg BW/day)			(μg/cm²/day)			(mg/kg BW/day)						
Benzo(a)anthracene		3.96E-09	8.58E-09	6.78E-09	1.01E-05	2.18E-05	1.72E-05	7.96E-10	3.98E-10	7.96E-10	N/A	N/A	N/A	N/A
Benzo(a)pyrene		5.08E-09	8.83E-09	7.53E-09	1.29E-05	2.24E-05	1.91E-05	1.99E-11	1.99E-11	3.98E-11	N/A	N/A	N/A	N/A
Benzo(b)fluoranthene		2.30E-09	8.47E-09	8.15E-09	5.85E-06	2.15E-05	2.07E-05	1.99E-10	1.99E-10	3.98E-10	N/A	N/A	N/A	N/A
Benzo(g,h,i)perylene		3.73E-09	5.15E-09	5.11E-09	9.46E-06	1.31E-05	1.30E-05	3.98E-10	3.98E-10	7.96E-10	N/A	N/A	N/A	N/A
Benzo(j)fluoranthene		1.11E-08	1.10E-08	1.38E-08	2.81E-05	2.79E-05	3.50E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(k)fluoranthene		2.68E-09	3.95E-09	4.87E-09	6.80E-06	1.00E-05	1.24E-05	1.99E-10	1.99E-10	3.98E-10	N/A	N/A	N/A	N/A
Chrysene		1.16E-08	8.96E-09	6.45E-09	2.94E-05	2.27E-05	1.64E-05	3.98E-10	1.99E-10	3.98E-10	N/A	N/A	N/A	N/A
Dibenzo(a,h)anthracene		1.21E-09	1.43E-09	1.56E-09	3.08E-06	3.62E-06	3.95E-06	3.98E-10	3.98E-10	7.96E-10	N/A	N/A	N/A	N/A
Indeno(1,2,3-c,d)pyrene		6.77E-09	5.71E-09	5.70E-09	1.72E-05	1.45E-05	1.45E-05	3.98E-10	3.98E-10	7.96E-10	N/A	N/A	N/A	N/A

Notes:

μg/cm²/day = microgram per square centimetre per day; ADAF = age-dependent adjustment factor; COPC = contaminant of potential concern; KIH = Kingston Inner Harbour; mg/kg BW/day = milligram per kilogram body weight per day; PAHs = polycyclic aromatic hydrocarbons; PCBs = polychlorinated biphenyls.

N/A = not applicable

TODDLER

Risk Estimates - Non-Carcinogenic

COPC	MEDIA	HQs (unitless)													TOTAL HQ [1]			TOTAL HQ [1]		
		SEDIMENT						SURFACE WATER						FOOD (FISH)						
	PATHWAY	INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO]			DERMAL CONTACT WITH BEDDED SEDIMENTS			INCIDENTAL INGESTION [DEEP WATER SCENARIO]			DERMAL CONTACT			FISH INGESTION	SHALLOW WATER/SHORELINE SCENARIO			DEEP WATER SCENARIO		
	EXPOSURE AREA OF WESTERN KIH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	ALL	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH
Aluminum		1.1E-03	1.5E-03	2.0E-03	3.4E-04	4.6E-04	6.3E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.4E-03	2.0E-03	2.6E-03	N/A	N/A	N/A
Antimony		4.0E-04	8.1E-04	4.4E-04	1.2E-03	2.5E-03	1.4E-03	5.4E-03	5.4E-03	1.1E-02	6.6E-04	6.6E-04	1.3E-03	N/A	7.7E-03	9.4E-03	1.4E-02	6.1E-03	6.1E-03	1.2E-02
Arsenic		1.4E-03	1.5E-02	5.1E-03	1.3E-03	1.4E-02	4.8E-03	2.2E-03	2.2E-03	4.3E-03	2.7E-04	2.7E-04	5.3E-04	1.1E-02	1.6E-02	4.2E-02	2.6E-02	1.3E-02	1.3E-02	1.6E-02
Chromium		8.2E-05	3.7E-05	4.0E-05	2.5E-04	1.1E-04	1.2E-04	1.0E-03	6.3E-06	5.8E-07	1.3E-04	7.7E-07	7.1E-08	7.2E-02	7.4E-02	7.2E-02	7.2E-02	7.3E-02	7.2E-02	7.2E-02
Cobalt		N/A	1.6E-03	N/A	N/A	5.1E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.2E-03	N/A	N/A	N/A	N/A
Lead		1.8E-02	2.1E-02	3.4E-02	3.3E-03	4.0E-03	6.3E-03	1.5E-01	5.6E-03	1.2E-03	1.8E-03	6.9E-05	1.5E-05	4.4E-01	6.1E-01	4.7E-01	4.8E-01	5.9E-01	4.5E-01	4.4E-01
Manganese		2.6E-04	4.2E-04	6.6E-04	8.2E-05	1.3E-04	2.1E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.5E-04	5.5E-04	8.7E-04	N/A	N/A	N/A
Mercury		6.4E-05	3.2E-04	3.3E-04	2.0E-03	9.9E-03	1.0E-02	N/A	N/A	N/A	N/A	N/A	N/A	**6.1E-01**	**6.2E-01**	**6.2E-01**	**6.2E-01**	**6.1E-01**	**6.1E-01**	**6.1E-01**
Vanadium		4.5E-04	7.4E-04	1.0E-03	1.4E-03	2.3E-03	3.3E-03	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.9E-03	3.0E-03	4.3E-03	N/A	N/A	N/A
Total PCBs		1.7E-04	2.2E-04	4.6E-04	7.3E-04	9.4E-04	2.0E-03	1.6E-04	2.7E-05	6.7E-05	N/A	N/A	N/A	**1.0E+00**	**1.0E+00**	**1.0E+00**	**1.0E+00**	**1.0E+00**	**1.0E+00**	**1.0E+00**

Early Life Stage Cancer Risk Estimates

COPC	MEDIA	ILCRs (unitless)													TOTAL ILCR [1]			TOTAL ILCR [1]		
		SEDIMENT						SURFACE WATER						FOOD (FISH)						
	PATHWAY	INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO]			DERMAL CONTACT WITH BEDDED SEDIMENTS			INCIDENTAL INGESTION [DEEP WATER SCENARIO]			DERMAL CONTACT			FISH INGESTION	SHALLOW WATER/SHORELINE SCENARIO			DEEP WATER SCENARIO		
	EXPOSURE AREA OF WESTERN KIH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	ALL	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH
Arsenic		1.4E-08	1.5E-07	5.0E-08	1.3E-08	1.4E-07	4.7E-08	2.1E-08	2.1E-08	4.3E-08	2.6E-09	2.6E-09	5.3E-09	3.3E-07	3.8E-07	6.4E-07	4.7E-07	3.5E-07	3.5E-07	3.8E-07
PAHs																				
Benzo(a)anthracene		1.8E-10	3.9E-10	3.1E-10	7.0E-07	1.5E-06	1.2E-06	3.7E-11	1.8E-11	3.7E-11	N/A	N/A	N/A	N/A	7.0E-07	1.5E-06	1.2E-06	3.7E-11	1.8E-11	3.7E-11
Benzo(a)pyrene		2.3E-09	4.1E-09	3.5E-09	9.0E-06	**1.6E-05**	**1.3E-05**	9.2E-12	9.2E-12	1.8E-11	N/A	N/A	N/A	N/A	9.0E-06	**1.6E-05**	**1.3E-05**	9.2E-12	9.2E-12	1.8E-11
Benzo(b)fluoranthene		1.1E-10	3.9E-10	3.8E-10	4.1E-07	1.5E-06	1.4E-06	9.2E-12	9.2E-12	1.8E-11	N/A	N/A	N/A	N/A	4.1E-07	1.5E-06	1.4E-06	9.2E-12	9.2E-12	1.8E-11
Benzo(g,h,i)perylene		1.7E-11	2.4E-11	2.4E-11	6.6E-08	9.1E-08	9.1E-08	1.8E-12	1.8E-12	3.7E-12	N/A	N/A	N/A	N/A	6.6E-08	9.2E-08	9.1E-08	1.8E-12	1.8E-12	3.7E-12
Benzo(j)fluoranthene		5.1E-10	5.1E-10	6.3E-10	2.0E-06	2.0E-06	2.4E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.0E-06	2.0E-06	2.4E-06	N/A	N/A	N/A
Benzo(k)fluoranthene		1.2E-10	1.8E-10	2.2E-10	4.8E-07	7.0E-07	8.6E-07	9.2E-12	9.2E-12	1.8E-11	N/A	N/A	N/A	N/A	4.8E-07	7.0E-07	8.6E-07	9.2E-12	9.2E-12	1.8E-11
Chrysene		5.3E-11	4.1E-11	3.0E-11	2.1E-07	1.6E-07	1.1E-07	1.8E-12	9.2E-13	1.8E-12	N/A	N/A	N/A	N/A	2.1E-07	1.6E-07	1.1E-07	1.8E-12	9.2E-13	1.8E-12
Dibenzo(a,h)anthracene		5.6E-10	6.6E-10	7.2E-10	2.2E-06	2.5E-06	2.8E-06	1.8E-10	1.8E-10	3.7E-10	N/A	N/A	N/A	N/A	2.2E-06	2.5E-06	2.8E-06	1.8E-10	1.8E-10	3.7E-10
Indeno(1,2,3-c,d)pyrene		3.1E-10	2.6E-10	2.6E-10	1.2E-06	1.0E-06	1.0E-06	1.8E-11	1.8E-11	3.7E-11	N/A	N/A	N/A	N/A	1.2E-06	1.0E-06	1.0E-06	1.8E-11	1.8E-11	3.7E-11
ILCRs for Short-Term Exposures (Incorporating ADAFs)																				
Benzo(a)anthracene		9.1E-10	2.0E-09	1.6E-09	3.5E-06	7.6E-06	6.0E-06	1.8E-10	9.2E-11	1.8E-10	N/A	N/A	N/A	N/A	3.5E-06	7.6E-06	6.0E-06	1.8E-10	9.2E-11	1.8E-10
Benzo(a)pyrene		1.2E-08	2.0E-08	1.7E-08	**4.5E-05**	**7.8E-05**	**6.7E-05**	4.6E-11	4.6E-11	9.2E-11	N/A	N/A	N/A	N/A	**4.5E-05**	**7.8E-05**	**6.7E-05**	4.6E-11	4.6E-11	9.2E-11
Benzo(b)fluoranthene		5.3E-10	1.9E-09	1.9E-09	2.0E-06	7.5E-06	7.2E-06	4.6E-11	4.6E-11	9.2E-11	N/A	N/A	N/A	N/A	2.0E-06	7.5E-06	7.2E-06	4.6E-11	4.6E-11	9.2E-11
Benzo(g,h,i)perylene		8.6E-11	1.2E-10	1.2E-10	3.3E-07	4.6E-07	4.5E-07	9.2E-12	9.2E-12	1.8E-11	N/A	N/A	N/A	N/A	3.3E-07	4.6E-07	4.5E-07	9.2E-12	9.2E-12	1.8E-11
Benzo(j)fluoranthene		2.5E-09	2.5E-09	3.2E-09	9.8E-06	9.8E-06	**1.2E-05**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9.8E-06	9.8E-06	**1.2E-05**	N/A	N/A	N/A
Benzo(k)fluoranthene		6.2E-10	9.1E-10	1.1E-09	2.4E-06	3.5E-06	4.3E-06	4.6E-11	4.6E-11	9.2E-11	N/A	N/A	N/A	N/A	2.4E-06	3.5E-06	4.3E-06	4.6E-11	4.6E-11	9.2E-11
Chrysene		2.7E-10	2.1E-10	1.5E-10	1.0E-06	8.0E-07	5.7E-07	9.2E-12	4.6E-12	9.2E-12	N/A	N/A	N/A	N/A	1.0E-06	8.0E-07	5.7E-07	9.2E-12	4.6E-12	9.2E-12
Dibenzo(a,h)anthracene		2.8E-09	3.3E-09	3.6E-09	**1.1E-05**	**1.3E-05**	**1.4E-05**	9.2E-10	9.2E-10	1.8E-09	N/A	N/A	N/A	N/A	**1.1E-05**	**1.3E-05**	**1.4E-05**	9.2E-10	9.2E-10	1.8E-09
Indeno(1,2,3-c,d)pyrene		1.6E-09	1.3E-09	1.3E-09	6.0E-06	5.1E-06	5.1E-06	9.2E-11	9.2E-11	1.8E-10	N/A	N/A	N/A	N/A	6.0E-06	5.1E-06	5.1E-06	9.2E-11	9.2E-11	1.8E-10

Notes:

ADAF = age-dependent adjustment factor; COPC = contaminant of potential concern; HQ = hazard quotient; ILCR = incremental lifetime cancer risk; KIH = Kingston Inner Harbour; PAHs = polycyclic aromatic hydrocarbons; PCBs = polychlorinated biphenyls.

N/A = not applicable

1 - The total HQ and ILCR include the sum of risks from the relevant pathways for each exposure area. For the shallow water/shoreline scenario, the following pathways were included in total risk estimate (where relevant): incidental ingestion of suspended sediments, dermal contact with bedded sediments, dermal contact with surface water, and fish ingestion. For the deep water scenario, the following pathways were included in total HQ (where relevant): incidental ingestion of surface water, dermal contact with surface water, and fish ingestion.

Shaded & Bolded = HQs is greater than 0.2 or ILCR is greater than 1.0E-05

Table 7: Dose and Risk Estimates for the Child
Human Health Risk Refinement
Kingston Inner Harbour

CHILD

Dose Estimates - Non-Carcinogenic

COPC	MEDIA	EXPOSURE DOSE												
		SEDIMENT						SURFACE WATER						FOOD (FISH)
	PATHWAY	INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO] (mg/kg BW/day)			DERMAL CONTACT WITH BEDDED SEDIMENTS (mg/kg BW/day)			INCIDENTAL INGESTION [DEEP WATER SCENARIO] (mg/kg BW/day)			DERMAL CONTACT (mg/kg BW/day)			FISH INGESTION (mg/kg BW/day)
	EXPOSURE AREA OF WESTERN KIH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	ALL
Aluminum		5.47E-04	7.46E-04	1.01E-03	2.86E-04	3.90E-04	5.25E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Antimony		8.01E-08	1.62E-07	8.84E-08	4.18E-07	8.44E-07	4.62E-07	1.09E-06	1.09E-06	2.17E-06	2.20E-07	2.20E-07	4.40E-07	N/A
Arsenic		2.12E-07	2.26E-06	7.65E-07	3.31E-07	3.54E-06	1.20E-06	3.26E-07	3.26E-07	6.51E-07	6.60E-08	6.60E-08	1.32E-07	2.71E-06
Chromium		6.14E-05	2.77E-05	2.97E-05	3.20E-04	1.44E-04	1.55E-04	7.74E-04	4.73E-06	4.34E-07	1.57E-04	9.60E-07	8.81E-08	5.43E-05
Cobalt		N/A	1.15E-06	N/A	N/A	6.02E-07	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lead		5.31E-06	6.46E-06	1.01E-05	1.66E-06	2.02E-06	3.17E-06	4.39E-05	1.70E-06	3.69E-07	8.89E-07	3.45E-08	7.49E-09	2.23E-04
Manganese		1.80E-05	2.85E-05	4.52E-05	9.42E-06	1.49E-05	2.36E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mercury		9.56E-09	4.79E-08	5.04E-08	4.99E-07	2.50E-06	2.63E-06	N/A	N/A	N/A	N/A	N/A	N/A	1.03E-04
Vanadium		1.13E-06	1.86E-06	2.62E-06	5.91E-06	9.69E-06	1.37E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total PCBs		1.09E-08	1.41E-08	3.02E-08	7.99E-08	1.03E-07	2.20E-07	1.07E-08	1.78E-09	4.34E-09	N/A	N/A	N/A	1.10E-04

Dose Estimates - Carcinogenic

COPC	MEDIA	EXPOSURE DOSE												
		SEDIMENT						SURFACE WATER						FOOD (FISH)
	PATHWAY	INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO]			DERMAL CONTACT WITH BEDDED SEDIMENTS			INCIDENTAL INGESTION [DEEP WATER SCENARIO]			DERMAL CONTACT			FISH INGESTION
	EXPOSURE AREA OF WESTERN KIH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	ALL
		(mg/kg BW/day)			(mg/kg BW/day)			(mg/kg BW/day)			(mg/kg BW/day)			(mg/kg BW/day)
Arsenic		6.05E-09	6.46E-08	2.19E-08	9.48E-09	1.01E-07	3.43E-08	9.32E-09	9.32E-09	1.86E-08	1.89E-09	1.89E-09	3.78E-09	2.37E-07
		Average Daily Dose												
PAHs		(mg/kg BW/day)			(µg/cm^2/day)			(mg/kg BW/day)						
Benzo(a)anthracene		6.18E-10	1.34E-09	1.06E-09	5.24E-06	1.13E-05	8.96E-06	1.24E-10	6.21E-11	1.24E-10	N/A	N/A	N/A	N/A
Benzo(a)pyrene		7.93E-10	1.38E-09	1.17E-09	6.72E-06	1.17E-05	9.95E-06	3.11E-12	3.11E-12	6.21E-12	N/A	N/A	N/A	N/A
Benzo(b)fluoranthene		3.60E-10	1.32E-09	1.27E-09	3.05E-06	1.12E-05	1.08E-05	3.11E-11	3.11E-11	6.21E-11	N/A	N/A	N/A	N/A
Benzo(g,h,i)perylene		5.82E-10	8.03E-10	7.98E-10	4.93E-06	6.81E-06	6.76E-06	6.21E-11	6.21E-11	1.24E-10	N/A	N/A	N/A	N/A
Benzo(j)fluoranthene		1.73E-09	1.72E-09	2.15E-09	1.47E-05	1.45E-05	1.82E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(k)fluoranthene		4.18E-10	6.17E-10	7.59E-10	3.54E-06	5.23E-06	6.43E-06	3.11E-11	3.11E-11	6.21E-11	N/A	N/A	N/A	N/A
Chrysene		1.81E-09	1.40E-09	1.01E-09	1.53E-05	1.18E-05	8.53E-06	6.21E-11	3.11E-11	6.21E-11	N/A	N/A	N/A	N/A
Dibenzo(a,h)anthracene		1.89E-10	2.23E-10	2.43E-10	1.60E-06	1.89E-06	2.06E-06	6.21E-11	6.21E-11	1.24E-10	N/A	N/A	N/A	N/A
Indeno(1,2,3-c,d)pyrene		1.06E-09	8.91E-10	8.89E-10	8.96E-06	7.55E-06	7.54E-06	6.21E-11	6.21E-11	1.24E-10	N/A	N/A	N/A	N/A
		Average Daily Dose for Short-Term Exposures (Incorporating ADAF)												
PAHs		(mg/kg BW/day)			(µg/cm^2/day)			(mg/kg BW/day)						
Benzo(a)anthracene		1.85E-09	4.01E-09	3.17E-09	1.57E-05	3.40E-05	2.69E-05	3.73E-10	1.86E-10	3.73E-10	N/A	N/A	N/A	N/A
Benzo(a)pyrene		2.38E-09	4.13E-09	3.52E-09	2.02E-05	3.50E-05	2.99E-05	9.32E-12	9.32E-12	1.86E-11	N/A	N/A	N/A	N/A
Benzo(b)fluoranthene		1.08E-09	3.97E-09	3.82E-09	9.14E-06	3.36E-05	3.23E-05	9.32E-11	9.32E-11	1.86E-10	N/A	N/A	N/A	N/A
Benzo(g,h,i)perylene		1.74E-09	2.41E-09	2.39E-09	1.48E-05	2.04E-05	2.03E-05	1.86E-10	1.86E-10	3.73E-10	N/A	N/A	N/A	N/A
Benzo(j)fluoranthene		5.19E-09	5.15E-09	6.45E-09	4.40E-05	4.36E-05	5.47E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(k)fluoranthene		1.25E-09	1.85E-09	2.28E-09	1.06E-05	1.57E-05	1.93E-05	9.32E-11	9.32E-11	1.86E-10	N/A	N/A	N/A	N/A
Chrysene		5.43E-09	4.19E-09	3.02E-09	4.60E-05	3.55E-05	2.56E-05	1.86E-10	9.32E-11	1.86E-10	N/A	N/A	N/A	N/A
Dibenzo(a,h)anthracene		5.68E-10	6.69E-10	7.29E-10	4.81E-06	5.66E-06	6.18E-06	1.86E-10	1.86E-10	3.73E-10	N/A	N/A	N/A	N/A
Indeno(1,2,3-c,d)pyrene		3.17E-09	2.67E-09	2.67E-09	2.69E-05	2.27E-05	2.26E-05	1.86E-10	1.86E-10	3.73E-10	N/A	N/A	N/A	N/A

Notes:

µg/cm^2/day = microgram per square centimetre per day; ADAF = age-dependent adjustment factor; COPC = contaminant of potential concern; KIH = Kingston Inner Harbour; mg/kg BW/day = milligram per kilogram body weight per day; PAHs = polycyclic aromatic hydrocarbons; PCBs = polychlorinated biphenyls.

N/A = not applicable

Table 7: Dose and Risk Estimates for the Child
Human Health Risk Refinement
Kingston Inner Harbour

CHILD

Risk Estimates - Non-Carcinogenic

COPC	MEDIA	HQs (unitless)													TOTAL HQ [1]			TOTAL HQ [1]		
		SEDIMENT						SURFACE WATER						FOOD (FISH)						
	PATHWAY	INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO]			DERMAL CONTACT WITH BEDDED SEDIMENTS			INCIDENTAL INGESTION [DEEP WATER SCENARIO]			DERMAL CONTACT			FISH INGESTION	SHALLOW WATER/SHORELINE SCENARIO			DEEP WATER SCENARIO		
	EXPOSURE AREA OF WESTERN KIH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	ALL	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH
Aluminum		5.5E-04	7.5E-04	1.0E-03	2.9E-04	3.9E-04	5.2E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8.3E-04	1.1E-03	1.5E-03	N/A	N/A	N/A
Antimony		2.0E-04	4.0E-04	2.2E-04	1.0E-03	2.1E-03	1.2E-03	2.7E-03	2.7E-03	5.4E-03	5.5E-04	5.5E-04	1.1E-03	N/A	4.5E-03	5.8E-03	7.9E-03	3.3E-03	3.3E-03	6.5E-03
Arsenic		7.1E-04	7.5E-03	2.5E-03	1.1E-03	1.2E-02	4.0E-03	1.1E-03	1.1E-03	2.2E-03	2.2E-04	2.2E-04	4.4E-04	9.0E-03	1.2E-02	3.0E-02	1.8E-02	1.0E-02	1.0E-02	1.2E-02
Chromium		4.1E-05	1.8E-05	2.0E-05	2.1E-04	9.6E-05	1.0E-04	5.2E-04	3.2E-06	2.9E-07	1.0E-04	6.4E-07	5.9E-08	6.0E-02	6.1E-02	6.0E-02	6.0E-02	6.1E-02	6.0E-02	6.0E-02
Cobalt		N/A	8.2E-04	N/A	N/A	4.3E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.3E-03	N/A	N/A	N/A	N/A
Lead		8.8E-03	1.1E-02	1.7E-02	2.8E-03	3.4E-03	5.3E-03	7.3E-02	2.8E-03	6.2E-04	1.5E-03	5.7E-05	1.2E-05	3.7E-01	4.6E-01	3.9E-01	3.9E-01	4.5E-01	3.7E-01	3.7E-01
Manganese		1.5E-04	2.3E-04	3.7E-04	7.7E-05	1.2E-04	1.9E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.3E-04	3.6E-04	5.6E-04	N/A	N/A	N/A
Mercury		3.2E-05	1.6E-04	1.7E-04	1.7E-03	8.3E-03	8.8E-03	N/A	N/A	N/A	N/A	N/A	N/A	**5.1E-01**	**5.1E-01**	**5.2E-01**	**5.2E-01**	**5.1E-01**	**5.1E-01**	**5.1E-01**
Vanadium		2.3E-04	3.7E-04	5.2E-04	1.2E-03	1.9E-03	2.7E-03	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.4E-03	2.3E-03	3.3E-03	N/A	N/A	N/A
Total PCBs		8.4E-05	1.1E-04	2.3E-04	6.1E-04	7.9E-04	1.7E-03	8.2E-05	1.4E-05	3.3E-05	N/A	N/A	N/A	**8.4E-01**	**8.4E-01**	**8.4E-01**	**8.5E-01**	**8.4E-01**	**8.4E-01**	**8.4E-01**

Early Life Stage Cancer Risk Estimates

COPC	MEDIA	ILCRs (unitless)													TOTAL ILCR [1]			TOTAL ILCR [1]		
		SEDIMENT						SURFACE WATER						FOOD (FISH)						
	PATHWAY	INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO]			DERMAL CONTACT WITH BEDDED SEDIMENTS			INCIDENTAL INGESTION [DEEP WATER SCENARIO]			DERMAL CONTACT			FISH INGESTION	SHALLOW WATER/SHORELINE SCENARIO			DEEP WATER SCENARIO		
	EXPOSURE AREA OF WESTERN KIH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	ALL	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH
Arsenic		1.1E-08	1.2E-07	3.9E-08	1.7E-08	1.8E-07	6.2E-08	1.7E-08	1.7E-08	3.4E-08	3.4E-09	3.4E-09	6.8E-09	4.3E-07	4.8E-07	7.5E-07	5.7E-07	4.5E-07	4.5E-07	4.7E-07
PAHs																				
Benzo(a)anthracene		1.4E-10	3.1E-10	2.4E-10	1.8E-06	4.0E-06	3.1E-06	2.9E-11	1.4E-11	2.9E-11	N/A	N/A	N/A	N/A	1.8E-06	4.0E-06	3.1E-06	2.9E-11	1.4E-11	2.9E-11
Benzo(a)pyrene		1.8E-09	3.2E-09	2.7E-09	**2.4E-05**	**4.1E-05**	**3.5E-05**	7.1E-12	7.1E-12	1.4E-11	N/A	N/A	N/A	N/A	**2.4E-05**	**4.1E-05**	**3.5E-05**	7.1E-12	7.1E-12	1.4E-11
Benzo(b)fluoranthene		8.3E-11	3.0E-10	2.9E-10	1.1E-06	3.9E-06	3.8E-06	7.1E-12	7.1E-12	1.4E-11	N/A	N/A	N/A	N/A	1.1E-06	3.9E-06	3.8E-06	7.1E-12	7.1E-12	1.4E-11
Benzo(g,h,i)perylene		1.3E-11	1.8E-11	1.8E-11	1.7E-07	2.4E-07	2.4E-07	1.4E-12	1.4E-12	2.9E-12	N/A	N/A	N/A	N/A	1.7E-07	2.4E-07	2.4E-07	1.4E-12	1.4E-12	2.9E-12
Benzo(j)fluoranthene		4.0E-10	3.9E-10	4.9E-10	5.1E-06	5.1E-06	6.4E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.1E-06	5.1E-06	6.4E-06	N/A	N/A	N/A
Benzo(k)fluoranthene		9.6E-11	1.4E-10	1.7E-10	1.2E-06	1.8E-06	2.3E-06	7.1E-12	7.1E-12	1.4E-11	N/A	N/A	N/A	N/A	1.2E-06	1.8E-06	2.3E-06	7.1E-12	7.1E-12	1.4E-11
Chrysene		4.2E-11	3.2E-11	2.3E-11	5.4E-07	4.1E-07	3.0E-07	1.4E-12	7.1E-13	1.4E-12	N/A	N/A	N/A	N/A	5.4E-07	4.1E-07	3.0E-07	1.4E-12	7.1E-13	1.4E-12
Dibenzo(a,h)anthracene		4.4E-10	5.1E-10	5.6E-10	5.6E-06	6.6E-06	7.2E-06	1.4E-10	1.4E-10	2.9E-10	N/A	N/A	N/A	N/A	5.6E-06	6.6E-06	7.2E-06	1.4E-10	1.4E-10	2.9E-10
Indeno(1,2,3-c,d)pyrene		2.4E-10	2.1E-10	2.0E-10	3.1E-06	2.6E-06	2.6E-06	1.4E-11	1.4E-11	2.9E-11	N/A	N/A	N/A	N/A	3.1E-06	2.6E-06	2.6E-06	1.4E-11	1.4E-11	2.9E-11
ILCRs for Short-Term Exposures (Incorporating ADAFs)																				
Benzo(a)anthracene		4.3E-10	9.2E-10	7.3E-10	5.5E-06	**1.2E-05**	9.4E-06	8.6E-11	4.3E-11	8.6E-11	N/A	N/A	N/A	N/A	5.5E-06	**1.2E-05**	9.4E-06	8.6E-11	4.3E-11	8.6E-11
Benzo(a)pyrene		5.5E-09	9.5E-09	8.1E-09	**7.1E-05**	**1.2E-04**	**1.0E-04**	2.1E-11	2.1E-11	4.3E-11	N/A	N/A	N/A	N/A	**7.1E-05**	**1.2E-04**	**1.0E-04**	2.1E-11	2.1E-11	4.3E-11
Benzo(b)fluoranthene		2.5E-10	9.1E-10	8.8E-10	3.2E-06	**1.2E-05**	**1.1E-05**	2.1E-11	2.1E-11	4.3E-11	N/A	N/A	N/A	N/A	3.2E-06	**1.2E-05**	**1.1E-05**	2.1E-11	2.1E-11	4.3E-11
Benzo(g,h,i)perylene		4.0E-11	5.5E-11	5.5E-11	5.2E-07	7.1E-07	7.1E-07	4.3E-12	4.3E-12	8.6E-12	N/A	N/A	N/A	N/A	5.2E-07	7.1E-07	7.1E-07	4.3E-12	4.3E-12	8.6E-12
Benzo(j)fluoranthene		1.2E-09	1.2E-09	1.5E-09	**1.5E-05**	**1.5E-05**	**1.9E-05**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**1.5E-05**	**1.5E-05**	**1.9E-05**	N/A	N/A	N/A
Benzo(k)fluoranthene		2.9E-10	4.3E-10	5.2E-10	3.7E-06	5.5E-06	6.8E-06	2.1E-11	2.1E-11	4.3E-11	N/A	N/A	N/A	N/A	3.7E-06	5.5E-06	6.8E-06	2.1E-11	2.1E-11	4.3E-11
Chrysene		1.2E-10	9.6E-11	6.9E-11	1.6E-06	1.2E-06	9.0E-07	4.3E-12	2.1E-12	4.3E-12	N/A	N/A	N/A	N/A	1.6E-06	1.2E-06	9.0E-07	4.3E-12	2.1E-12	4.3E-12
Dibenzo(a,h)anthracene		1.3E-09	1.5E-09	1.7E-09	**1.7E-05**	**2.0E-05**	**2.2E-05**	4.3E-10	4.3E-10	8.6E-10	N/A	N/A	N/A	N/A	**1.7E-05**	**2.0E-05**	**2.2E-05**	4.3E-10	4.3E-10	8.6E-10
Indeno(1,2,3-c,d)pyrene		7.3E-10	6.2E-10	6.1E-10	9.4E-06	7.9E-06	7.9E-06	4.3E-11	4.3E-11	8.6E-11	N/A	N/A	N/A	N/A	9.4E-06	7.9E-06	7.9E-06	4.3E-11	4.3E-11	8.6E-11

Notes:

ADAF = age-dependent adjustment factor; COPC = contaminant of potential concern; HQ = hazard quotient; ILCR = incremental lifetime cancer risk; KIH = Kingston Inner Harbour; PAHs = polycyclic aromatic hydrocarbons; PCBs = polychlorinated biphenyls.

N/A = not applicable

1 - The total HQ and ILCR include the sum of risks from the relevant pathways for each exposure area. For the shallow water/shoreline scenario, the following pathways were included in total risk estimate (where relevant): incidental ingestion of suspended sediments, dermal contact with bedded sediments, dermal contact with surface water, and fish ingestion. For the deep water scenario, the following pathways were included in total HQ (where relevant): incidental ingestion of surface water, dermal contact with surface water, and fish ingestion.

Shaded & Bolded = HQs is greater than 0.2 or ILCR is greater than 1.0E-05

Table 8: Dose and Risk Estimates for the Teen
Human Health Risk Refinement
Kingston Inner Harbour

TEEN

Dose Estimates - Non-Carcinogenic

COPC	MEDIA	EXPOSURE DOSE												
		SEDIMENT						SURFACE WATER						FOOD (FISH)
	PATHWAY	INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO] (mg/kg BW/day)			DERMAL CONTACT WITH BEDDED SEDIMENTS (mg/kg BW/day)			INCIDENTAL INGESTION [DEEP WATER SCENARIO] (mg/kg BW/day)			DERMAL CONTACT (mg/kg BW/day)			FISH INGESTION (mg/kg BW/day)
	EXPOSURE AREA OF WESTERN KIH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	ALL
Aluminum		3.01E-04	4.11E-04	5.54E-04	2.36E-04	3.22E-04	4.34E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Antimony		4.41E-08	8.91E-08	4.87E-08	3.46E-07	6.97E-07	3.82E-07	5.98E-07	5.98E-07	1.20E-06	1.85E-07	1.85E-07	3.70E-07	N/A
Arsenic		1.17E-07	1.24E-06	4.22E-07	2.74E-07	2.92E-06	9.90E-07	1.79E-07	1.79E-07	3.59E-07	5.55E-08	5.55E-08	1.11E-07	3.39E-06
Chromium		3.38E-05	1.52E-05	1.64E-05	2.65E-04	1.19E-04	1.28E-04	4.27E-04	2.61E-06	2.39E-07	1.32E-04	8.07E-07	7.40E-08	6.79E-05
Cobalt		N/A	6.35E-07	N/A	N/A	4.98E-07	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lead		2.93E-06	3.56E-06	5.57E-06	1.37E-06	1.67E-06	2.62E-06	2.42E-05	9.37E-07	2.03E-07	7.48E-07	2.90E-08	6.29E-09	2.78E-04
Manganese		9.94E-06	1.57E-05	2.49E-05	7.79E-06	1.23E-05	1.95E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mercury		5.27E-09	2.64E-08	2.77E-08	4.13E-07	2.07E-06	2.17E-06	N/A	N/A	N/A	N/A	N/A	N/A	1.28E-04
Vanadium		6.23E-07	1.02E-06	1.44E-06	4.88E-06	8.01E-06	1.13E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total PCBs		6.03E-09	7.78E-09	1.66E-08	6.61E-08	8.52E-08	1.82E-07	5.89E-09	9.81E-10	2.39E-09	N/A	N/A	N/A	1.37E-04

Dose Estimates - Carcinogenic

COPC	MEDIA	EXPOSURE DOSE												
		SEDIMENT						SURFACE WATER						FOOD (FISH)
	PATHWAY	INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO]			DERMAL CONTACT WITH BEDDED SEDIMENTS			INCIDENTAL INGESTION [DEEP WATER SCENARIO]			DERMAL CONTACT			FISH INGESTION
	EXPOSURE AREA OF WESTERN KIH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	ALL
		(mg/kg BW/day)			(mg/kg BW/day)			(mg/kg BW/day)			(mg/kg BW/day)			(mg/kg BW/day)
Arsenic		3.81E-09	4.07E-08	1.38E-08	8.96E-09	9.55E-08	3.24E-08	5.87E-09	5.87E-09	1.17E-08	1.82E-09	1.82E-09	3.63E-09	3.39E-07
		Average Daily Dose												
PAHs		(mg/kg BW/day)			(μg/cm^2/day)			(mg/kg BW/day)						
Benzo(a)anthracene		3.89E-10	8.43E-10	6.66E-10	8.98E-06	1.94E-05	1.54E-05	7.82E-11	3.91E-11	7.82E-11	N/A	N/A	N/A	N/A
Benzo(a)pyrene		4.99E-10	8.68E-10	7.40E-10	1.15E-05	2.00E-05	1.71E-05	1.96E-12	1.96E-12	3.91E-12	N/A	N/A	N/A	N/A
Benzo(b)fluoranthene		2.26E-10	8.32E-10	8.01E-10	5.22E-06	1.92E-05	1.85E-05	1.96E-11	1.96E-11	3.91E-11	N/A	N/A	N/A	N/A
Benzo(g,h,i)perylene		3.66E-10	5.06E-10	5.02E-10	8.45E-06	1.17E-05	1.16E-05	3.91E-11	3.91E-11	7.82E-11	N/A	N/A	N/A	N/A
Benzo(j)fluoranthene		1.09E-09	1.08E-09	1.35E-09	2.51E-05	2.49E-05	3.12E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(k)fluoranthene		2.63E-10	3.89E-10	4.78E-10	6.07E-06	8.96E-06	1.10E-05	1.96E-11	1.96E-11	3.91E-11	N/A	N/A	N/A	N/A
Chrysene		1.14E-09	8.80E-10	6.34E-10	2.63E-05	2.03E-05	1.46E-05	3.91E-11	1.96E-11	3.91E-11	N/A	N/A	N/A	N/A
Dibenzo(a,h)anthracene		1.19E-10	1.40E-10	1.53E-10	2.75E-06	3.24E-06	3.53E-06	3.91E-11	3.91E-11	7.82E-11	N/A	N/A	N/A	N/A
Indeno(1,2,3-c,d)pyrene		6.66E-10	5.61E-10	5.60E-10	1.54E-05	1.29E-05	1.29E-05	3.91E-11	3.91E-11	7.82E-11	N/A	N/A	N/A	N/A
		Average Daily Dose for Short-Term Exposures (Incorporating ADAF)												
PAHs		(mg/kg BW/day)			(μg/cm^2/day)			(mg/kg BW/day)						
Benzo(a)anthracene		7.78E-10	1.69E-09	1.33E-09	1.80E-05	3.89E-05	3.07E-05	1.56E-10	7.82E-11	1.56E-10	N/A	N/A	N/A	N/A
Benzo(a)pyrene		9.99E-10	1.74E-09	1.48E-09	2.30E-05	4.00E-05	3.41E-05	3.91E-12	3.91E-12	7.82E-12	N/A	N/A	N/A	N/A
Benzo(b)fluoranthene		4.53E-10	1.66E-09	1.60E-09	1.04E-05	3.84E-05	3.70E-05	3.91E-11	3.91E-11	7.82E-11	N/A	N/A	N/A	N/A
Benzo(g,h,i)perylene		7.32E-10	1.01E-09	1.00E-09	1.69E-05	2.33E-05	2.32E-05	7.82E-11	7.82E-11	1.56E-10	N/A	N/A	N/A	N/A
Benzo(j)fluoranthene		2.18E-09	2.16E-09	2.71E-09	5.02E-05	4.99E-05	6.25E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(k)fluoranthene		5.26E-10	7.77E-10	9.57E-10	1.21E-05	1.79E-05	2.21E-05	3.91E-11	3.91E-11	7.82E-11	N/A	N/A	N/A	N/A
Chrysene		2.28E-09	1.76E-09	1.27E-09	5.26E-05	4.06E-05	2.92E-05	7.82E-11	3.91E-11	7.82E-11	N/A	N/A	N/A	N/A
Dibenzo(a,h)anthracene		2.39E-10	2.81E-10	3.06E-10	5.50E-06	6.47E-06	7.06E-06	7.82E-11	7.82E-11	1.56E-10	N/A	N/A	N/A	N/A
Indeno(1,2,3-c,d)pyrene		1.33E-09	1.12E-09	1.12E-09	3.07E-05	2.59E-05	2.58E-05	7.82E-11	7.82E-11	1.56E-10	N/A	N/A	N/A	N/A

Notes:

μg/cm^2/day = microgram per square centimetre per day; ADAF = age-dependent adjustment factor; COPC = contaminant of potential concern; KIH = Kingston Inner Harbour; mg/kg BW/day = milligram per kilogram body weight per day; PAHs = polycyclic aromatic hydrocarbons; PCBs = polychlorinated biphenyls.

N/A = not applicable

TEEN

Risk Estimates - Non-Carcinogenic

COPC	MEDIA	HQs (unitless)													TOTAL HQ [1]			TOTAL HQ [1]		
		SEDIMENT						SURFACE WATER						FOOD (FISH)						
	PATHWAY	INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO]			DERMAL CONTACT WITH BEDDED SEDIMENTS			INCIDENTAL INGESTION [DEEP WATER SCENARIO]			DERMAL CONTACT			FISH INGESTION	SHALLOW WATER/SHORELINE SCENARIO			DEEP WATER SCENARIO		
	EXPOSURE AREA OF WESTERN KIH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	ALL	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH
Aluminum		3.0E-04	4.1E-04	5.5E-04	2.4E-04	3.2E-04	4.3E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.4E-04	7.3E-04	9.9E-04	N/A	N/A	N/A
Antimony		1.1E-04	2.2E-04	1.2E-04	8.6E-04	1.7E-03	9.5E-04	1.5E-03	1.5E-03	3.0E-03	4.6E-04	4.6E-04	9.3E-04	N/A	2.9E-03	3.9E-03	5.0E-03	2.0E-03	2.0E-03	3.9E-03
Arsenic		3.9E-04	4.1E-03	1.4E-03	9.1E-04	9.7E-03	3.3E-03	6.0E-04	6.0E-04	1.2E-03	1.9E-04	1.9E-04	3.7E-04	1.1E-02	1.3E-02	2.6E-02	1.8E-02	1.2E-02	1.2E-02	1.3E-02
Chromium		2.3E-05	1.0E-05	1.1E-05	1.8E-04	8.0E-05	8.6E-05	2.8E-04	1.7E-06	1.6E-07	8.8E-05	5.4E-07	4.9E-08	7.5E-02	7.6E-02	7.6E-02	7.6E-02	7.6E-02	7.5E-02	7.5E-02
Cobalt		N/A	4.5E-04	N/A	N/A	3.6E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8.1E-04	N/A	N/A	N/A	N/A
Lead		2.3E-03	2.7E-03	4.3E-03	1.1E-03	1.3E-03	2.0E-03	1.9E-02	7.2E-04	1.6E-04	5.8E-04	2.2E-05	4.8E-06	2.1E-01	2.4E-01	2.2E-01	2.2E-01	2.3E-01	2.1E-01	2.1E-01
Manganese		7.0E-05	1.1E-04	1.8E-04	5.5E-05	8.7E-05	1.4E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.2E-04	2.0E-04	3.1E-04	N/A	N/A	N/A
Mercury		1.8E-05	8.8E-05	9.2E-05	1.4E-03	6.9E-03	7.2E-03	N/A	N/A	N/A	N/A	N/A	N/A	**2.7E-01**	**2.7E-01**	**2.8E-01**	**2.8E-01**	**2.7E-01**	**2.7E-01**	**2.7E-01**
Vanadium		1.2E-04	2.0E-04	2.9E-04	9.8E-04	1.6E-03	2.3E-03	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.1E-03	1.8E-03	2.6E-03	N/A	N/A	N/A
Total PCBs		4.6E-05	6.0E-05	1.3E-04	5.1E-04	6.6E-04	1.4E-03	4.5E-05	7.5E-06	1.8E-05	N/A	N/A	N/A	**1.1E+00**	**1.1E+00**	**1.1E+00**	**1.1E+00**	**1.1E+00**	**1.1E+00**	**1.1E+00**

Early Life Stage Cancer Risk Estimates

COPC	MEDIA	ILCRs (unitless)													TOTAL ILCR [1]			TOTAL ILCR [1]		
		SEDIMENT						SURFACE WATER						FOOD (FISH)						
	PATHWAY	INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO]			DERMAL CONTACT WITH BEDDED SEDIMENTS			INCIDENTAL INGESTION [DEEP WATER SCENARIO]			DERMAL CONTACT			FISH INGESTION	SHALLOW WATER/SHORELINE SCENARIO			DEEP WATER SCENARIO		
	EXPOSURE AREA OF WESTERN KIH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	ALL	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH
Arsenic		6.9E-09	7.3E-08	2.5E-08	1.6E-08	1.7E-07	5.8E-08	1.1E-08	1.1E-08	2.1E-08	3.3E-09	3.3E-09	6.5E-09	6.1E-07	6.5E-07	8.7E-07	7.2E-07	6.2E-07	6.2E-07	6.4E-07
PAHs																				
Benzo(a)anthracene		9.0E-11	1.9E-10	1.5E-10	3.1E-06	6.8E-06	5.4E-06	1.8E-11	9.0E-12	1.8E-11	N/A	N/A	N/A	N/A	3.1E-06	6.8E-06	5.4E-06	1.8E-11	9.0E-12	1.8E-11
Benzo(a)pyrene		1.1E-09	2.0E-09	1.7E-09	**4.0E-05**	**7.0E-05**	**6.0E-05**	4.5E-12	4.5E-12	9.0E-12	N/A	N/A	N/A	N/A	**4.0E-05**	**7.0E-05**	**6.0E-05**	4.5E-12	4.5E-12	9.0E-12
Benzo(b)fluoranthene		5.2E-11	1.9E-10	1.8E-10	1.8E-06	6.7E-06	6.5E-06	4.5E-12	4.5E-12	9.0E-12	N/A	N/A	N/A	N/A	1.8E-06	6.7E-06	6.5E-06	4.5E-12	4.5E-12	9.0E-12
Benzo(g,h,i)perylene		8.4E-12	1.2E-11	1.2E-11	3.0E-07	4.1E-07	4.1E-07	9.0E-13	9.0E-13	1.8E-12	N/A	N/A	N/A	N/A	3.0E-07	4.1E-07	4.1E-07	9.0E-13	9.0E-13	1.8E-12
Benzo(j)fluoranthene		2.5E-10	2.5E-10	3.1E-10	8.8E-06	8.7E-06	**1.1E-05**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8.8E-06	8.7E-06	**1.1E-05**	N/A	N/A	N/A
Benzo(k)fluoranthene		6.1E-11	8.9E-11	1.1E-10	2.1E-06	3.1E-06	3.9E-06	4.5E-12	4.5E-12	9.0E-12	N/A	N/A	N/A	N/A	2.1E-06	3.1E-06	3.9E-06	4.5E-12	4.5E-12	9.0E-12
Chrysene		2.6E-11	2.0E-11	1.5E-11	9.2E-07	7.1E-07	5.1E-07	9.0E-13	4.5E-13	9.0E-13	N/A	N/A	N/A	N/A	9.2E-07	7.1E-07	5.1E-07	9.0E-13	4.5E-13	9.0E-13
Dibenzo(a,h)anthracene		2.7E-10	3.2E-10	3.5E-10	9.6E-06	**1.1E-05**	**1.2E-05**	9.0E-11	9.0E-11	1.8E-10	N/A	N/A	N/A	N/A	9.6E-06	**1.1E-05**	**1.2E-05**	9.0E-11	9.0E-11	1.8E-10
Indeno(1,2,3-c,d)pyrene		1.5E-10	1.3E-10	1.3E-10	5.4E-06	4.5E-06	4.5E-06	9.0E-12	9.0E-12	1.8E-11	N/A	N/A	N/A	N/A	5.4E-06	4.5E-06	4.5E-06	9.0E-12	9.0E-12	1.8E-11
ILCRs for Short-Term Exposures (Incorporating ADAFs)																				
Benzo(a)anthracene		1.8E-10	3.9E-10	3.1E-10	6.3E-06	**1.4E-05**	**1.1E-05**	3.6E-11	1.8E-11	3.6E-11	N/A	N/A	N/A	N/A	6.3E-06	**1.4E-05**	**1.1E-05**	3.6E-11	1.8E-11	3.6E-11
Benzo(a)pyrene		2.3E-09	4.0E-09	3.4E-09	**8.1E-05**	**1.4E-04**	**1.2E-04**	9.0E-12	9.0E-12	1.8E-11	N/A	N/A	N/A	N/A	**8.1E-05**	**1.4E-04**	**1.2E-04**	9.0E-12	9.0E-12	1.8E-11
Benzo(b)fluoranthene		1.0E-10	3.8E-10	3.7E-10	3.7E-06	**1.3E-05**	**1.3E-05**	9.0E-12	9.0E-12	1.8E-11	N/A	N/A	N/A	N/A	3.7E-06	**1.3E-05**	**1.3E-05**	9.0E-12	9.0E-12	1.8E-11
Benzo(g,h,i)perylene		1.7E-11	2.3E-11	2.3E-11	5.9E-07	8.2E-07	8.1E-07	1.8E-12	1.8E-12	3.6E-12	N/A	N/A	N/A	N/A	5.9E-07	8.2E-07	8.1E-07	1.8E-12	1.8E-12	3.6E-12
Benzo(j)fluoranthene		5.0E-10	5.0E-10	6.2E-10	**1.8E-05**	**1.7E-05**	**2.2E-05**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**1.8E-05**	**1.7E-05**	**2.2E-05**	N/A	N/A	N/A
Benzo(k)fluoranthene		1.2E-10	1.8E-10	2.2E-10	4.2E-06	6.3E-06	7.7E-06	9.0E-12	9.0E-12	1.8E-11	N/A	N/A	N/A	N/A	4.3E-06	6.3E-06	7.7E-06	9.0E-12	9.0E-12	1.8E-11
Chrysene		5.2E-11	4.0E-11	2.9E-11	1.8E-06	1.4E-06	1.0E-06	1.8E-12	9.0E-13	1.8E-12	N/A	N/A	N/A	N/A	1.8E-06	1.4E-06	1.0E-06	1.8E-12	9.0E-13	1.8E-12
Dibenzo(a,h)anthracene		5.5E-10	6.5E-10	7.0E-10	**1.9E-05**	**2.3E-05**	**2.5E-05**	1.8E-10	1.8E-10	3.6E-10	N/A	N/A	N/A	N/A	**1.9E-05**	**2.3E-05**	**2.5E-05**	1.8E-10	1.8E-10	3.6E-10
Indeno(1,2,3-c,d)pyrene		3.1E-10	2.6E-10	2.6E-10	**1.1E-05**	9.1E-06	9.0E-06	1.8E-11	1.8E-11	3.6E-11	N/A	N/A	N/A	N/A	**1.1E-05**	9.1E-06	9.0E-06	1.8E-11	1.8E-11	3.6E-11

Notes:

ADAF = age-dependent adjustment factor; COPC = contaminant of potential concern; HQ = hazard quotient; ILCR = incremental lifetime cancer risk; KIH = Kingston Inner Harbour; PAHs = polycyclic aromatic hydrocarbons; PCBs = polychlorinated biphenyls.

N/A = not applicable

1 - The total HQ and ILCR include the sum of risks from the relevant pathways for each exposure area. For the shallow water/shoreline scenario, the following pathways were included in total risk estimate (where relevant): incidental ingestion of suspended sediments, dermal contact with bedded sediments, dermal contact with surface water, and fish ingestion. For the deep water scenario, the following pathways were included in total HQ (where relevant): incidental ingestion of surface water, dermal contact with surface water, and fish ingestion.

Shaded & Bolded = HQs is greater than 0.2 or ILCR is greater than 1.0E-05

ADULT

Dose Estimates - Non-Carcinogenic

COPC	MEDIA	EXPOSURE DOSE												
		SEDIMENT						SURFACE WATER						FOOD (FISH)
	PATHWAY	INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO] (mg/kg BW/day)			DERMAL CONTACT WITH BEDDED SEDIMENTS (mg/kg BW/day)			INCIDENTAL INGESTION [DEEP WATER SCENARIO] (mg/kg BW/day)			DERMAL CONTACT (mg/kg BW/day)			FISH INGESTION (mg/kg BW/day)
	EXPOSURE AREA OF WESTERN KIH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	ALL
Aluminum		2.55E-04	3.47E-04	4.68E-04	2.21E-04	3.02E-04	4.07E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Antimony		3.73E-08	7.52E-08	4.11E-08	3.24E-07	6.54E-07	3.58E-07	5.05E-07	5.05E-07	1.01E-06	1.78E-07	1.78E-07	3.56E-07	N/A
Arsenic		9.85E-08	1.05E-06	3.56E-07	2.57E-07	2.74E-06	9.29E-07	1.52E-07	1.52E-07	3.03E-07	5.35E-08	5.35E-08	1.07E-07	2.87E-06
Chromium		2.86E-05	1.29E-05	1.38E-05	2.48E-04	1.12E-04	1.20E-04	3.60E-04	2.20E-06	2.02E-07	1.27E-04	7.77E-07	7.13E-08	5.73E-05
Cobalt		N/A	5.37E-07	N/A	N/A	4.67E-07	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lead		2.47E-06	3.00E-06	4.70E-06	1.29E-06	1.57E-06	2.45E-06	2.04E-05	7.91E-07	1.72E-07	7.20E-07	2.79E-08	6.06E-09	2.35E-04
Manganese		8.40E-06	1.33E-05	2.10E-05	7.31E-06	1.15E-05	1.83E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mercury		4.45E-09	2.23E-08	2.34E-08	3.87E-07	1.94E-06	2.04E-06	N/A	N/A	N/A	N/A	N/A	N/A	1.08E-04
Vanadium		5.26E-07	8.64E-07	1.22E-06	4.58E-06	7.51E-06	1.06E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total PCBs		5.09E-09	6.57E-09	1.40E-08	6.20E-08	8.00E-08	1.71E-07	4.98E-09	8.28E-10	2.02E-09	N/A	N/A	N/A	1.16E-04

Dose Estimates - Carcinogenic

COPC	MEDIA	EXPOSURE DOSE												
		SEDIMENT						SURFACE WATER						FOOD (FISH)
	PATHWAY	INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO]			DERMAL CONTACT WITH BEDDED SEDIMENTS			INCIDENTAL INGESTION [DEEP WATER SCENARIO]			DERMAL CONTACT			FISH INGESTION
	EXPOSURE AREA OF WESTERN KIH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	ALL
		(mg/kg BW/day)			(mg/kg BW/day)			(mg/kg BW/day)			(mg/kg BW/day)			(mg/kg BW/day)
Arsenic		2.41E-08	2.58E-07	8.73E-08	6.30E-08	6.72E-07	2.28E-07	3.72E-08	3.72E-08	7.43E-08	1.31E-08	1.31E-08	2.62E-08	2.15E-06
		Average Daily Dose												
PAHs		(mg/kg BW/day)			(µg/cm^2/day)			(mg/kg BW/day)						
Benzo(a)anthracene		2.46E-09	5.34E-09	4.22E-09	7.48E-05	1.62E-04	1.28E-04	4.95E-10	2.48E-10	4.95E-10	N/A	N/A	N/A	N/A
Benzo(a)pyrene		3.16E-09	5.50E-09	4.68E-09	9.60E-05	1.67E-04	1.42E-04	1.24E-11	1.24E-11	2.48E-11	N/A	N/A	N/A	N/A
Benzo(b)fluoranthene		1.43E-09	5.27E-09	5.07E-09	4.35E-05	1.60E-04	1.54E-04	1.24E-10	1.24E-10	2.48E-10	N/A	N/A	N/A	N/A
Benzo(g,h,i)perylene		2.32E-09	3.20E-09	3.18E-09	7.04E-05	9.73E-05	9.66E-05	2.48E-10	2.48E-10	4.95E-10	N/A	N/A	N/A	N/A
Benzo(j)fluoranthene		6.90E-09	6.85E-09	8.58E-09	2.09E-04	2.08E-04	2.60E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(k)fluoranthene		1.67E-09	2.46E-09	3.03E-09	5.06E-05	7.47E-05	9.19E-05	1.24E-10	1.24E-10	2.48E-10	N/A	N/A	N/A	N/A
Chrysene		7.22E-09	5.57E-09	4.01E-09	2.19E-04	1.69E-04	1.22E-04	2.48E-10	1.24E-10	2.48E-10	N/A	N/A	N/A	N/A
Dibenzo(a,h)anthracene		7.55E-10	8.89E-10	9.69E-10	2.29E-05	2.70E-05	2.94E-05	2.48E-10	2.48E-10	4.95E-10	N/A	N/A	N/A	N/A
Indeno(1,2,3-c,d)pyrene		4.22E-09	3.56E-09	3.55E-09	1.28E-04	1.08E-04	1.08E-04	2.48E-10	2.48E-10	4.95E-10	N/A	N/A	N/A	N/A
		Average Daily Dose for Short-Term Exposures (Incorporating ADAF)												
PAHs		(mg/kg BW/day)			(µg/cm^2/day)			(mg/kg BW/day)						
Benzo(a)anthracene		2.46E-09	5.34E-09	4.22E-09	7.48E-05	1.62E-04	1.28E-04	4.95E-10	2.48E-10	4.95E-10	N/A	N/A	N/A	N/A
Benzo(a)pyrene		3.16E-09	5.50E-09	4.68E-09	9.60E-05	1.67E-04	1.42E-04	1.24E-11	1.24E-11	2.48E-11	N/A	N/A	N/A	N/A
Benzo(b)fluoranthene		1.43E-09	5.27E-09	5.07E-09	4.35E-05	1.60E-04	1.54E-04	1.24E-10	1.24E-10	2.48E-10	N/A	N/A	N/A	N/A
Benzo(g,h,i)perylene		2.32E-09	3.20E-09	3.18E-09	7.04E-05	9.73E-05	9.66E-05	2.48E-10	2.48E-10	4.95E-10	N/A	N/A	N/A	N/A
Benzo(j)fluoranthene		6.90E-09	6.85E-09	8.58E-09	2.09E-04	2.08E-04	2.60E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(k)fluoranthene		1.67E-09	2.46E-09	3.03E-09	5.06E-05	7.47E-05	9.19E-05	1.24E-10	1.24E-10	2.48E-10	N/A	N/A	N/A	N/A
Chrysene		7.22E-09	5.57E-09	4.01E-09	2.19E-04	1.69E-04	1.22E-04	2.48E-10	1.24E-10	2.48E-10	N/A	N/A	N/A	N/A
Dibenzo(a,h)anthracene		7.55E-10	8.89E-10	9.69E-10	2.29E-05	2.70E-05	2.94E-05	2.48E-10	2.48E-10	4.95E-10	N/A	N/A	N/A	N/A
Indeno(1,2,3-c,d)pyrene		4.22E-09	3.56E-09	3.55E-09	1.28E-04	1.08E-04	1.08E-04	2.48E-10	2.48E-10	4.95E-10	N/A	N/A	N/A	N/A

Notes:

µg/cm^2/day = microgram per square centimetre per day; ADAF = age-dependent adjustment factor; COPC = contaminant of potential concern; KIH = Kingston Inner Harbour; mg/kg BW/day = milligram per kilogram body weight per day; PAHs = polycyclic aromatic hydrocarbons; PCBs = polychlorinated biphenyls.

N/A = not applicable

APPENDIX C
Table 9: Dose and Risk Estimates for the Adult
Human Health Risk Refinement
Kingston Inner Harbour

ADULT

Risk Estimates - Non-Carcinogenic

COPC	MEDIA / PATHWAY / EXPOSURE AREA OF WESTERN KIH	HQs (unitless) – SEDIMENT – INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO] – NORTH	CENTRAL	SOUTH	SEDIMENT – DERMAL CONTACT WITH BEDDED SEDIMENTS – NORTH	CENTRAL	SOUTH	SURFACE WATER – INCIDENTAL INGESTION [DEEP WATER SCENARIO] – NORTH	CENTRAL	SOUTH	SURFACE WATER – DERMAL CONTACT – NORTH	CENTRAL	SOUTH	FOOD (FISH) – FISH INGESTION – ALL	TOTAL HQ [1] – SHALLOW WATER/SHORELINE SCENARIO – NORTH	CENTRAL	SOUTH	TOTAL HQ [1] – DEEP WATER SCENARIO – NORTH	CENTRAL	SOUTH
Aluminum		2.5E-04	3.5E-04	4.7E-04	2.2E-04	3.0E-04	4.1E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4.8E-04	6.5E-04	8.8E-04	N/A	N/A	N/A
Antimony		9.3E-05	1.9E-04	1.0E-04	8.1E-04	1.6E-03	8.9E-04	1.3E-03	1.3E-03	2.5E-03	4.5E-04	4.5E-04	8.9E-04	N/A	2.6E-03	3.5E-03	4.4E-03	1.7E-03	1.7E-03	3.4E-03
Arsenic		3.3E-04	3.5E-03	1.2E-03	8.6E-04	9.1E-03	3.1E-03	5.1E-04	5.1E-04	1.0E-03	1.8E-04	1.8E-04	3.6E-04	9.6E-03	1.1E-02	2.3E-02	1.5E-02	1.0E-02	1.0E-02	1.1E-02
Chromium		1.9E-05	8.6E-06	9.2E-06	1.7E-04	7.5E-05	8.0E-05	2.4E-04	1.5E-06	1.3E-07	8.5E-05	5.2E-07	4.8E-08	6.4E-02	6.4E-02	6.4E-02	6.4E-02	6.4E-02	6.4E-02	6.4E-02
Cobalt		N/A	3.8E-04	N/A	N/A	3.3E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.2E-04	N/A	N/A	N/A	N/A
Lead		1.9E-03	2.3E-03	3.6E-03	9.9E-04	1.2E-03	1.9E-03	1.6E-02	6.1E-04	1.3E-04	5.5E-04	2.1E-05	4.7E-06	1.8E-01	2.0E-01	1.8E-01	1.9E-01	2.0E-01	1.8E-01	1.8E-01
Manganese		5.4E-05	8.5E-05	1.3E-04	4.7E-05	7.4E-05	1.2E-04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.0E-04	1.6E-04	2.5E-04	N/A	N/A	N/A
Mercury	**MeHg TRV for**	1.5E-05	7.4E-05	7.8E-05	1.3E-03	6.5E-03	6.8E-03	N/A	N/A	N/A	N/A	N/A	N/A	**5.4E-01**	**5.4E-01**	**5.5E-01**	**5.5E-01**	**5.4E-01**	**5.4E-01**	**5.4E-01**
Vanadium		1.1E-04	1.7E-04	2.4E-04	9.2E-04	1.5E-03	2.1E-03	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.0E-03	1.7E-03	2.4E-03	N/A	N/A	N/A
Total PCBs		3.9E-05	5.1E-05	1.1E-04	4.8E-04	6.2E-04	1.3E-03	3.8E-05	6.4E-06	1.6E-05	N/A	N/A	N/A	**8.9E-01**	**8.9E-01**	**8.9E-01**	**8.9E-01**	**8.9E-01**	**8.9E-01**	**8.9E-01**

Early Life Stage Cancer Risk Estimates

COPC	MEDIA / PATHWAY / EXPOSURE AREA OF WESTERN KIH	ILCRs (unitless) – SEDIMENT – INCIDENTAL INGESTION OF SUSPENDED SEDIMENTS [SHALLOW WATER/SHORELINE SCENARIO] – NORTH	CENTRAL	SOUTH	SEDIMENT – DERMAL CONTACT WITH BEDDED SEDIMENTS – NORTH	CENTRAL	SOUTH	SURFACE WATER – INCIDENTAL INGESTION [DEEP WATER SCENARIO] – NORTH	CENTRAL	SOUTH	SURFACE WATER – DERMAL CONTACT – NORTH	CENTRAL	SOUTH	FOOD (FISH) – FISH INGESTION – ALL	TOTAL ILCR [1] – SHALLOW WATER/SHORELINE SCENARIO – NORTH	CENTRAL	SOUTH	TOTAL ILCR [1] – DEEP WATER SCENARIO – NORTH	CENTRAL	SOUTH
Arsenic		4.3E-08	4.6E-07	1.6E-07	1.1E-07	1.2E-06	4.1E-07	6.7E-08	6.7E-08	1.3E-07	2.4E-08	2.4E-08	4.7E-08	3.9E-06	4.1E-06	5.6E-06	4.6E-06	4.0E-06	4.0E-06	4.1E-06
PAHs																				
Benzo(a)anthracene		5.7E-10	1.2E-09	9.7E-10	**2.6E-05**	**5.7E-05**	**4.5E-05**	1.1E-10	5.7E-11	1.1E-10	N/A	N/A	N/A	N/A	**2.6E-05**	**5.7E-05**	**4.5E-05**	1.1E-10	5.7E-11	1.1E-10
Benzo(a)pyrene		7.3E-09	1.3E-08	1.1E-08	**3.4E-04**	**5.8E-04**	**5.0E-04**	2.8E-11	2.8E-11	5.7E-11	N/A	N/A	N/A	N/A	**3.4E-04**	**5.8E-04**	**5.0E-04**	2.8E-11	2.8E-11	5.7E-11
Benzo(b)fluoranthene		3.3E-10	1.2E-09	1.2E-09	**1.5E-05**	**5.6E-05**	**5.4E-05**	2.8E-11	2.8E-11	5.7E-11	N/A	N/A	N/A	N/A	**1.5E-05**	**5.6E-05**	**5.4E-05**	2.8E-11	2.8E-11	5.7E-11
Benzo(g,h,i)perylene		5.3E-11	7.4E-11	7.3E-11	2.5E-06	3.4E-06	3.4E-06	5.7E-12	5.7E-12	1.1E-11	N/A	N/A	N/A	N/A	2.5E-06	3.4E-06	3.4E-06	5.7E-12	5.7E-12	1.1E-11
Benzo(j)fluoranthene		1.6E-09	1.6E-09	2.0E-09	**7.3E-05**	**7.3E-05**	**9.1E-05**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**7.3E-05**	**7.3E-05**	**9.1E-05**	N/A	N/A	N/A
Benzo(k)fluoranthene		3.8E-10	5.7E-10	7.0E-10	**1.8E-05**	**2.6E-05**	**3.2E-05**	2.8E-11	2.8E-11	5.7E-11	N/A	N/A	N/A	N/A	**1.8E-05**	**2.6E-05**	**3.2E-05**	2.8E-11	2.8E-11	5.7E-11
Chrysene		1.7E-10	1.3E-10	9.2E-11	7.7E-06	5.9E-06	4.3E-06	5.7E-12	2.8E-12	5.7E-12	N/A	N/A	N/A	N/A	7.7E-06	5.9E-06	4.3E-06	5.7E-12	2.8E-12	5.7E-12
Dibenzo(a,h)anthracene		1.7E-09	2.0E-09	2.2E-09	**8.0E-05**	**9.4E-05**	**1.0E-04**	5.7E-10	5.7E-10	1.1E-09	N/A	N/A	N/A	N/A	**8.0E-05**	**9.4E-05**	**1.0E-04**	5.7E-10	5.7E-10	1.1E-09
Indeno(1,2,3-c,d)pyrene		9.7E-10	8.2E-10	8.2E-10	**4.5E-05**	**3.8E-05**	**3.8E-05**	5.7E-11	5.7E-11	1.1E-10	N/A	N/A	N/A	N/A	**4.5E-05**	**3.8E-05**	**3.8E-05**	5.7E-11	5.7E-11	1.1E-10
ILCRs for Short-Term Exposures (Incorporating ADAFs)																				
Benzo(a)anthracene		5.7E-10	1.2E-09	9.7E-10	**2.6E-05**	**5.7E-05**	**4.5E-05**	1.1E-10	5.7E-11	1.1E-10	N/A	N/A	N/A	N/A	**2.6E-05**	**5.7E-05**	**4.5E-05**	1.1E-10	5.7E-11	1.1E-10
Benzo(a)pyrene		7.3E-09	1.3E-08	1.1E-08	**3.4E-04**	**5.8E-04**	**5.0E-04**	2.8E-11	2.8E-11	5.7E-11	N/A	N/A	N/A	N/A	**3.4E-04**	**5.8E-04**	**5.0E-04**	2.8E-11	2.8E-11	5.7E-11
Benzo(b)fluoranthene		3.3E-10	1.2E-09	1.2E-09	**1.5E-05**	**5.6E-05**	**5.4E-05**	2.8E-11	2.8E-11	5.7E-11	N/A	N/A	N/A	N/A	**1.5E-05**	**5.6E-05**	**5.4E-05**	2.8E-11	2.8E-11	5.7E-11
Benzo(g,h,i)perylene		5.3E-11	7.4E-11	7.3E-11	2.5E-06	3.4E-06	3.4E-06	5.7E-12	5.7E-12	1.1E-11	N/A	N/A	N/A	N/A	2.5E-06	3.4E-06	3.4E-06	5.7E-12	5.7E-12	1.1E-11
Benzo(j)fluoranthene		1.6E-09	1.6E-09	2.0E-09	**7.3E-05**	**7.3E-05**	**9.1E-05**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**7.3E-05**	**7.3E-05**	**9.1E-05**	N/A	N/A	N/A
Benzo(k)fluoranthene		3.8E-10	5.7E-10	7.0E-10	**1.8E-05**	**2.6E-05**	**3.2E-05**	2.8E-11	2.8E-11	5.7E-11	N/A	N/A	N/A	N/A	**1.8E-05**	**2.6E-05**	**3.2E-05**	2.8E-11	2.8E-11	5.7E-11
Chrysene		1.7E-10	1.3E-10	9.2E-11	7.7E-06	5.9E-06	4.3E-06	5.7E-12	2.8E-12	5.7E-12	N/A	N/A	N/A	N/A	7.7E-06	5.9E-06	4.3E-06	5.7E-12	2.8E-12	5.7E-12
Dibenzo(a,h)anthracene		1.7E-09	2.0E-09	2.2E-09	**8.0E-05**	**9.4E-05**	**1.0E-04**	5.7E-10	5.7E-10	1.1E-09	N/A	N/A	N/A	N/A	**8.0E-05**	**9.4E-05**	**1.0E-04**	5.7E-10	5.7E-10	1.1E-09
Indeno(1,2,3-c,d)pyrene		9.7E-10	8.2E-10	8.2E-10	**4.5E-05**	**3.8E-05**	**3.8E-05**	5.7E-11	5.7E-11	1.1E-10	N/A	N/A	N/A	N/A	**4.5E-05**	**3.8E-05**	**3.8E-05**	5.7E-11	5.7E-11	1.1E-10

Notes:

ADAF = age-dependent adjustment factor; COPC = contaminant of potential concern; HQ = hazard quotient; ILCR = incremental lifetime cancer risk; KIH = Kingston Inner Harbour; PAHs = polycyclic aromatic hydrocarbons; PCBs = polychlorinated biphenyls.

N/A = not applicable

1 - The total HQ and ILCR include the sum of risks from the relevant pathways for each exposure area. For the shallow water/shoreline scenario, the following pathways were included in total risk estimate (where relevant): incidental ingestion of suspended sediments, dermal contact with bedded sediments, dermal contact with surface water, and fish ingestion. For the deep water scenario, the following pathways were included in total HQ (where relevant): incidental ingestion of surface water, dermal contact with surface water, and fish ingestion.

Shaded & Bolded = HQs is greater than 0.2 or ILCR is greater than 1.0E-05

APPENDIX C
Table 10: Summary of Risk Estimates
Human Health Risk Refinement
Kingston Inner Harbour

Risk Estimates - Non-Carcinogenic

	Shallow Water/Shoreline Scenario											
	TODDLER			CHILD			TEEN			ADULT		
COPC	TOTAL HQ			TOTAL HQ			TOTAL HQ			TOTAL HQ		
	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH
Aluminum	1.4E-03	2.0E-03	2.6E-03	8.3E-04	1.1E-03	1.5E-03	5.4E-04	7.3E-04	9.9E-04	4.8E-04	6.5E-04	8.8E-04
Antimony	7.7E-03	9.4E-03	1.4E-02	4.5E-03	5.8E-03	7.9E-03	2.9E-03	3.9E-03	5.0E-03	2.6E-03	3.5E-03	4.4E-03
Arsenic	1.6E-02	4.2E-02	2.6E-02	1.2E-02	3.0E-02	1.8E-02	1.3E-02	2.6E-02	1.8E-02	1.1E-02	2.3E-02	1.5E-02
Chromium	7.4E-02	7.2E-02	7.2E-02	6.1E-02	6.0E-02	6.0E-02	7.6E-02	7.6E-02	7.6E-02	6.4E-02	6.4E-02	6.4E-02
Cobalt	N/A	2.2E-03	N/A	N/A	1.3E-03	N/A	N/A	8.1E-04	N/A	N/A	7.2E-04	N/A
Lead	6.1E-01	4.7E-01	4.8E-01	4.6E-01	3.9E-01	3.9E-01	2.4E-01	2.2E-01	2.2E-01	2.0E-01	1.8E-01	1.9E-01
Manganese	3.5E-04	5.5E-04	8.7E-04	2.3E-04	3.6E-04	5.6E-04	1.2E-04	2.0E-04	3.1E-04	1.0E-04	1.6E-04	2.5E-04
Mercury	**6.2E-01**	**6.2E-01**	**6.2E-01**	**5.1E-01**	**5.2E-01**	**5.2E-01**	**2.7E-01**	**2.8E-01**	**2.8E-01**	**5.4E-01**	**5.5E-01**	**5.5E-01**
Vanadium	1.9E-03	3.0E-03	4.3E-03	1.4E-03	2.3E-03	3.3E-03	1.1E-03	1.8E-03	2.6E-03	1.0E-03	1.7E-03	2.4E-03
Total PCBs	**1.0E+00**	**1.0E+00**	**1.0E+00**	**8.4E-01**	**8.4E-01**	**8.5E-01**	**1.1E+00**	**1.1E+00**	**1.1E+00**	**8.9E-01**	**8.9E-01**	**8.9E-01**

Risk Estimates - Carcinogenic

	Shallow Water/Shoreline Scenario														
	TODDLER			CHILD			TEEN			ADULT			CUMULATIVE ILCR		
COPC	TOTAL ILCR			TOTAL ILCR			TOTAL ILCR			TOTAL ILCR					
	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH
Arsenic	3.8E-07	6.4E-07	4.7E-07	4.8E-07	7.5E-07	5.7E-07	6.5E-07	8.7E-07	7.2E-07	4.1E-06	5.6E-06	4.6E-06	5.6E-06	7.9E-06	6.4E-06
Carcinogenic PAHs															
Benzo(a)anthracene	7.0E-07	1.5E-06	1.2E-06	1.8E-06	4.0E-06	3.1E-06	3.1E-06	6.8E-06	5.4E-06	**2.6E-05**	**5.7E-05**	**4.5E-05**	**3.2E-05**	**6.9E-05**	**5.5E-05**
Benzo(a)pyrene	9.0E-06	**1.6E-05**	**1.3E-05**	**2.4E-05**	**4.1E-05**	**3.5E-05**	**4.0E-05**	**7.0E-05**	**6.0E-05**	**3.4E-04**	**5.8E-04**	**5.0E-04**	**4.1E-04**	**7.1E-04**	**6.1E-04**
Benzo(b)fluoranthene	4.1E-07	1.5E-06	1.4E-06	1.1E-06	3.9E-06	3.8E-06	1.8E-06	6.7E-06	6.5E-06	**1.5E-05**	**5.6E-05**	**5.4E-05**	**1.9E-05**	**6.8E-05**	**6.6E-05**
Benzo(g,h,i)perylene	6.6E-08	9.2E-08	9.1E-08	1.7E-07	2.4E-07	2.4E-07	3.0E-07	4.1E-07	4.1E-07	2.5E-06	3.4E-06	3.4E-06	3.0E-06	4.1E-06	4.1E-06
Benzo(j)fluoranthene	2.0E-06	2.0E-06	2.4E-06	5.1E-06	5.1E-06	6.4E-06	8.8E-06	8.7E-06	**1.1E-05**	**7.3E-05**	**7.3E-05**	**9.1E-05**	**8.9E-05**	**8.9E-05**	**1.1E-04**
Benzo(k)fluoranthene	4.8E-07	7.0E-07	8.6E-07	1.2E-06	1.8E-06	2.3E-06	2.1E-06	3.1E-06	3.9E-06	**1.8E-05**	**2.6E-05**	**3.2E-05**	**2.2E-05**	**3.2E-05**	**3.9E-05**
Chrysene	2.1E-07	1.6E-07	1.1E-07	5.4E-07	4.1E-07	3.0E-07	9.2E-07	7.1E-07	5.1E-07	7.7E-06	5.9E-06	4.3E-06	9.3E-06	7.2E-06	5.2E-06
Dibenzo(a,h)anthracene	2.2E-06	2.5E-06	2.8E-06	5.6E-06	6.6E-06	7.2E-06	9.6E-06	**1.1E-05**	**1.2E-05**	**8.0E-05**	**9.4E-05**	**1.0E-04**	**9.8E-05**	**1.1E-04**	**1.3E-04**
Indeno(1,2,3-c,d)pyrene	1.2E-06	1.0E-06	1.0E-06	3.1E-06	2.6E-06	2.6E-06	5.4E-06	4.5E-06	4.5E-06	**4.5E-05**	**3.8E-05**	**3.8E-05**	**5.4E-05**	**4.6E-05**	**4.6E-05**
Total Carcinogenic PAHs	**1.6E-05**	**2.5E-05**	**2.3E-05**	**4.2E-05**	**6.6E-05**	**6.1E-05**	**7.2E-05**	**1.1E-04**	**1.0E-04**	**6.0E-04**	**9.4E-04**	**8.7E-04**	**7.3E-04**	**1.1E-03**	**1.1E-03**

Carcinogenic PAHs	Short Term Carcinogenic Exposures to PAHs														
Benzo(a)anthracene	3.5E-06	7.6E-06	6.0E-06	5.5E-06	**1.2E-05**	9.4E-06	6.3E-06	**1.4E-05**	**1.1E-05**	**2.6E-05**	**5.7E-05**	**4.5E-05**	**4.1E-05**	**9.0E-05**	**7.1E-05**
Benzo(a)pyrene	**4.5E-05**	**7.8E-05**	**6.7E-05**	**7.1E-05**	**1.2E-04**	**1.0E-04**	**8.1E-05**	**1.4E-04**	**1.2E-04**	**3.4E-04**	**5.8E-04**	**5.0E-04**	**5.3E-04**	**9.3E-04**	**7.9E-04**
Benzo(b)fluoranthene	2.0E-06	7.5E-06	7.2E-06	3.2E-06	**1.2E-05**	**1.1E-05**	3.7E-06	**1.3E-05**	**1.3E-05**	**1.5E-05**	**5.6E-05**	**5.4E-05**	**2.4E-05**	**8.9E-05**	**8.5E-05**
Benzo(g,h,i)perylene	3.3E-07	4.6E-07	4.5E-07	5.2E-07	7.1E-07	7.1E-07	5.9E-07	8.2E-07	8.1E-07	2.5E-06	3.4E-06	3.4E-06	3.9E-06	5.4E-06	5.4E-06
Benzo(j)fluoranthene	9.8E-06	9.8E-06	**1.2E-05**	**1.5E-05**	**1.5E-05**	**1.9E-05**	**1.8E-05**	**1.7E-05**	**2.2E-05**	**7.3E-05**	**7.3E-05**	**9.1E-05**	**1.2E-04**	**1.2E-04**	**1.4E-04**
Benzo(k)fluoranthene	2.4E-06	3.5E-06	4.3E-06	3.7E-06	5.5E-06	6.8E-06	4.3E-06	6.3E-06	7.7E-06	**1.8E-05**	**2.6E-05**	**3.2E-05**	**2.8E-05**	**4.1E-05**	**5.1E-05**
Chrysene	1.0E-06	8.0E-07	5.7E-07	1.6E-06	1.2E-06	9.0E-07	1.8E-06	1.4E-06	1.0E-06	7.7E-06	5.9E-06	4.3E-06	**1.2E-05**	9.4E-06	6.8E-06
Dibenzo(a,h)anthracene	**1.1E-05**	**1.3E-05**	**1.4E-05**	**1.7E-05**	**2.0E-05**	**2.2E-05**	**1.9E-05**	**2.3E-05**	**2.5E-05**	**8.0E-05**	**9.4E-05**	**1.0E-04**	**1.3E-04**	**1.5E-04**	**1.6E-04**
Indeno(1,2,3-c,d)pyrene	6.0E-06	5.1E-06	5.1E-06	9.4E-06	7.9E-06	7.9E-06	**1.1E-05**	9.1E-06	9.0E-06	**4.5E-05**	**3.8E-05**	**3.8E-05**	**7.1E-05**	**6.0E-05**	**6.0E-05**
Total Carcinogenic PAHs	**8.1E-05**	**1.3E-04**	**1.2E-04**	**1.3E-04**	**2.0E-04**	**1.8E-04**	**1.4E-04**	**2.2E-04**	**2.1E-04**	**6.0E-04**	**9.4E-04**	**8.7E-04**	**9.6E-04**	**1.5E-03**	**1.4E-03**

Notes:
COPC = contaminant of potential concern; HQ = hazard quotient; ILCR = incremental lifetime cancer risk; PAHs = polycyclic aromatic hydrocarbons; PCBs = polychlorinated biphenyls.
Shaded & Bolded = HQ greater than 0.2 or ILCR greater than 1.0E-05

Table 10: Summary of Risk Estimates
Human Health Risk Refinement
Kingston Inner Harbour

Risk Estimates - Non-Carcinogenic

COPC	Deep Water Scenario											
	TODDLER			CHILD			TEEN			ADULT		
	TOTAL HQ			TOTAL HQ			TOTAL HQ			TOTAL HQ		
	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH
Aluminum	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Antimony	6.1E-03	6.1E-03	1.2E-02	3.3E-03	3.3E-03	6.5E-03	2.0E-03	2.0E-03	3.9E-03	1.7E-03	1.7E-03	3.4E-03
Arsenic	1.3E-02	1.3E-02	1.6E-02	1.0E-02	1.0E-02	1.2E-02	1.2E-02	1.2E-02	1.3E-02	1.0E-02	1.0E-02	1.1E-02
Chromium	7.3E-02	7.2E-02	7.2E-02	6.1E-02	6.0E-02	6.0E-02	7.6E-02	7.5E-02	7.5E-02	6.4E-02	6.4E-02	6.4E-02
Cobalt	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lead	5.9E-01	4.5E-01	4.4E-01	4.5E-01	3.7E-01	3.7E-01	2.3E-01	2.1E-01	2.1E-01	2.0E-01	1.8E-01	1.8E-01
Manganese	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mercury	**6.1E-01**	**6.1E-01**	**6.1E-01**	**5.1E-01**	**5.1E-01**	**5.1E-01**	**2.7E-01**	**2.7E-01**	**2.7E-01**	**5.4E-01**	**5.4E-01**	**5.4E-01**
Vanadium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total PCBs	**1.0E+00**	**1.0E+00**	**1.0E+00**	**8.4E-01**	**8.4E-01**	**8.4E-01**	**1.1E+00**	**1.1E+00**	**1.1E+00**	**8.9E-01**	**8.9E-01**	**8.9E-01**

Risk Estimates - Carcinogenic

COPC	Deep Water Scenario														
	TODDLER			CHILD			TEEN			ADULT			CUMULATIVE ILCR		
	TOTAL ILCR			TOTAL ILCR			TOTAL ILCR			TOTAL ILCR					
	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH
Arsenic	3.5E-07	3.5E-07	3.8E-07	4.5E-07	4.5E-07	4.7E-07	6.2E-07	6.2E-07	6.4E-07	4.0E-06	4.0E-06	4.1E-06	5.4E-06	5.4E-06	5.5E-06
Carcinogenic PAHs															
Benzo(a)anthracene	3.7E-11	1.8E-11	3.7E-11	2.9E-11	1.4E-11	2.9E-11	1.8E-11	9.0E-12	1.8E-11	1.1E-10	5.7E-11	1.1E-10	2.0E-10	9.9E-11	2.0E-10
Benzo(a)pyrene	9.2E-12	9.2E-12	1.8E-11	7.1E-12	7.1E-12	1.4E-11	4.5E-12	4.5E-12	9.0E-12	2.8E-11	2.8E-11	5.7E-11	4.9E-11	4.9E-11	9.9E-11
Benzo(b)fluoranthene	9.2E-12	9.2E-12	1.8E-11	7.1E-12	7.1E-12	1.4E-11	4.5E-12	4.5E-12	9.0E-12	2.8E-11	2.8E-11	5.7E-11	4.9E-11	4.9E-11	9.9E-11
Benzo(g,h,i)perylene	1.8E-12	1.8E-12	3.7E-12	1.4E-12	1.4E-12	2.9E-12	9.0E-13	9.0E-13	1.8E-12	5.7E-12	5.7E-12	1.1E-11	9.9E-12	9.9E-12	2.0E-11
Benzo(j)fluoranthene	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(k)fluoranthene	9.2E-12	9.2E-12	1.8E-11	7.1E-12	7.1E-12	1.4E-11	4.5E-12	4.5E-12	9.0E-12	2.8E-11	2.8E-11	5.7E-11	4.9E-11	4.9E-11	9.9E-11
Chrysene	1.8E-12	9.2E-13	1.8E-12	1.4E-12	7.1E-13	1.4E-12	9.0E-13	4.5E-13	9.0E-13	5.7E-12	2.8E-12	5.7E-12	9.9E-12	4.9E-12	9.9E-12
Dibenzo(a,h)anthracene	1.8E-10	1.8E-10	3.7E-10	1.4E-10	1.4E-10	2.9E-10	9.0E-11	9.0E-11	1.8E-10	5.7E-10	5.7E-10	1.1E-09	9.9E-10	9.9E-10	2.0E-09
Indeno(1,2,3-c,d)pyrene	1.8E-11	1.8E-11	3.7E-11	1.4E-11	1.4E-11	2.9E-11	9.0E-12	9.0E-12	1.8E-11	5.7E-11	5.7E-11	1.1E-10	9.9E-11	9.9E-11	2.0E-10
Total Carcinogenic PAHs	2.7E-10	2.5E-10	5.0E-10	2.1E-10	1.9E-10	3.9E-10	1.3E-10	1.2E-10	2.5E-10	8.4E-10	7.8E-10	1.6E-09	1.4E-09	1.3E-09	2.7E-09
Carcinogenic PAHs	**Short Term Carcinogenic Exposures to PAHs**														
Benzo(a)anthracene	1.8E-10	9.2E-11	1.8E-10	8.6E-11	4.3E-11	8.6E-11	3.6E-11	1.8E-11	3.6E-11	1.1E-10	5.7E-11	1.1E-10	4.2E-10	2.1E-10	4.2E-10
Benzo(a)pyrene	4.6E-11	4.6E-11	9.2E-11	2.1E-11	2.1E-11	4.3E-11	9.0E-12	9.0E-12	1.8E-11	2.8E-11	2.8E-11	5.7E-11	1.0E-10	1.0E-10	2.1E-10
Benzo(b)fluoranthene	4.6E-11	4.6E-11	9.2E-11	2.1E-11	2.1E-11	4.3E-11	9.0E-12	9.0E-12	1.8E-11	2.8E-11	2.8E-11	5.7E-11	1.0E-10	1.0E-10	2.1E-10
Benzo(g,h,i)perylene	9.2E-12	9.2E-12	1.8E-11	4.3E-12	4.3E-12	8.6E-12	1.8E-12	1.8E-12	3.6E-12	5.7E-12	5.7E-12	1.1E-11	2.1E-11	2.1E-11	4.2E-11
Benzo(j)fluoranthene	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(k)fluoranthene	4.6E-11	4.6E-11	9.2E-11	2.1E-11	2.1E-11	4.3E-11	9.0E-12	9.0E-12	1.8E-11	2.8E-11	2.8E-11	5.7E-11	1.0E-10	1.0E-10	2.1E-10
Chrysene	9.2E-12	4.6E-12	9.2E-12	4.3E-12	2.1E-12	4.3E-12	1.8E-12	9.0E-13	1.8E-12	5.7E-12	2.8E-12	5.7E-12	2.1E-11	1.0E-11	2.1E-11
Dibenzo(a,h)anthracene	9.2E-10	9.2E-10	1.8E-09	4.3E-10	4.3E-10	8.6E-10	1.8E-10	1.8E-10	3.6E-10	5.7E-10	5.7E-10	1.1E-09	2.1E-09	2.1E-09	4.2E-09
Indeno(1,2,3-c,d)pyrene	9.2E-11	9.2E-11	1.8E-10	4.3E-11	4.3E-11	8.6E-11	1.8E-11	1.8E-11	3.6E-11	5.7E-11	5.7E-11	1.1E-10	2.1E-10	2.1E-10	4.2E-10
Total Carcinogenic PAHs	1.3E-09	1.2E-09	2.5E-09	6.3E-10	5.8E-10	1.2E-09	2.6E-10	2.5E-10	4.9E-10	8.4E-10	7.8E-10	1.6E-09	3.1E-09	2.9E-09	5.7E-09

Notes:
COPC = contaminant of potential concern; HQ = hazard quotient; ILCR = incremental lifetime cancer risk; PAHs = polycyclic aromatic hydrocarbons; PCBs = polychlorinated biphenyls.

APPENDIX C
Table 10: Summary of Risk Estimates
Human Health Risk Refinement
Kingston Inner Harbour

Risk Estimates - Chemicals with Target Organ/System

		Shallow Water/Shoreline Scenario											
		TODDLER			CHILD			TEEN			ADULT		
COPCs	Target Organ/System	TOTAL HQ			TOTAL HQ			TOTAL HQ			TOTAL HQ		
		NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH
Methylmercury, Total PCBs	Nervous system	1.6E+00	1.6E+00	1.6E+00	1.4E+00	1.4E+00	1.4E+00	1.3E+00	1.3E+00	1.3E+00	1.4E+00	1.4E+00	1.4E+00

Notes:
COPC = contaminant of potential concern; HQ = hazard quotient; PCBs = polychlorinated biphenyls.

Risk Estimates - Chemicals with Target Organ/System

		Deep Water Scenario											
		TODDLER			CHILD			TEEN			ADULT		
COPCs	Target Organ/System	TOTAL HQ			TOTAL HQ			TOTAL HQ			TOTAL HQ		
		NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH	NORTH	CENTRAL	SOUTH
Methylmercury, Total PCBs	Nervous system	1.6E+00	1.6E+00	1.6E+00	1.4E+00	1.4E+00	1.4E+00	1.3E+00	1.3E+00	1.3E+00	1.4E+00	1.4E+00	1.4E+00

Notes:
COPC = contaminant of potential concern; HQ = hazard quotient; PCBs = polychlorinated biphenyls.

APPENDIX C
Table 11: Toxicicty Reference Values
Human Health Risk Assessment
Kingston Inner Harbour

Contaminant of Potential Concern	RAF[1]		Carcinogenic Classification				Non-carcinogenic							Carcinogenic							Likelihood of Exposures During a Sensitive Life Stage[8]	Whole Body Elimination Half Life
	Oral (unitless)	Dermal (unitless)	Health Canada[2]	IARC[3]	US EPA[4]	Assessed as a Carcinogen?	Oral RfD[5] (mg/kg/day)		Target Organ/System	Critical Effect & Mode of Action	Duration	Source	Developmental Toxicant?[6]	Oral SF $(mg/kg/day)^{-1}$	Dermal SF $(\mu g/cm^2/day)^{-1}$	Target Organ/System	Critical Effect & Mode of Action	Mutagenic?[7]	Duration	Source		
Aluminum	1	0.01	NC	NC	NC	No	1	all age groups	Nervous system	Decreased forelimb and hindlimb grip strength and decreased thermal sensitivity Aluminum can alter the function of the blood-brain barrier, however the MOA for is not well known (ATSDR 2008, HSDB 2010a).	Chronic (conception through 24 months)	ATSDR 2008	No	NA	NA	-	-	-	-	-	North - unlikely Central - unlikely South - low and possible	4.5 hours (HSDB 2010a)
Antimony	1	0.1	NC	NC	NC	No	0.0004	all age groups	Hematopoietic system	Decreased longevity, decreased non-fasting blood glucose levels and altered cholesterol levels. Antimony combines with sulfhydryl groups such as those in enzymes important for tissue respiration. The antidotal action of BAL depends on its ability to prevent or break the union between antimony and vital enzymes (HSDB 2005).	Chronic (duration of study not reported)	US EPA 1991	No	NA	NA	-	-	-	-	-	North - unlikely Central - unlikely South - low and possible	Thyroid 40 days; liver, lung, kidney 15 days (ATSDR 1992)
Arsenic	1	0.03	Group I	Group 1	Group A	**Yes**	0.0003	all age groups	Skin, vascular system	Hyperpigmentation, keratosis and possible vascular complications The MOA is unclear. Arsenic may induce alterations in nitric oxide metabolism and endothelial function (ATSDR 2007a).	Chronic (epidemiological study; duration not reported)	US EPA 1993	No	1.8	NA	Bladder, lung, liver	Cancer. Limited data on mode of action (Health Canada 2006)	No	Chronic (≤60 years)	Health Canada 2010	North - unlikely Central - unlikely South - low and possible	40 - 60 hours (ATSDR 2007a)
Chromium (III) (sediment and water contact pathways)	1	0.1	NC	Group 3	Group D	No	1.5	all age groups	NA	No effects observed Chromium may inhibit the action of hormones and enzymes through non-specific binding, changing the configuration of the active site (HSBD 2009).	Chronic (840 days)	US EPA 1998	No	NA	NA	-	-	-	-	-	North - unlikely Central - unlikely South - low and possible	10 hours (ATSDR 2012a)
Chromium (VI) (fish consumption pathway)	1	NA	NC[a]	Group 1	Group D[c]	No	0.0009	all age groups	Gastrointestinal tract	Diffuse epithelial enlargement of the duodenum. Chromium (VI) is readily reduced to chromium (III), with chromium (V) and chromium (IV) as intermediates. Chromium (V) and chromium(IV) may react with intracellular constituents, resulting in either the formation of free radicals or direct binding to macromolecules. This may result in DNA-protein crosslinks, DNA-DNA crosslinks, DNA strand breaks, lipid peroxidation and alterations in cellular signaling pathways (ATSDR 2012a).	Chronic (2 years)	ATSDR 2012a	No	NA	NA	-	-	-	-	-	North - unlikely Central - unlikely South - low and possible	39 hours (ATSDR 2012a)
Cobalt	1	0.01	NC	Group 2B	NC	No	0.0014	all age groups	Cardiovascular system	Cardiomyopathy (abnormal heart muscles) The MOA is unclear. Together with tungsten carbide exposure, tungsten may facilitate oxidation of cobalt to Co^{2+}, which increases its solubility. This may result in the generation of active oxygen species, which is then absorbed in the blood and carried throughout the body (ATSDR 2004).	Sub-chronic (8 months)	RIVM 2001	No	NA	NA	-	-	-	-	-	North - unlikely Central - unlikely South - low and possible	Elimination from tissues is assumed to follow three first-order rate constants that represent slow, medium, and fast, with half-times of 6, 80, and 600 days, respectively (WHO CICAD)
Lead	1	0.006	NC	Group 2A	Group B2	No	0.0006	infants, toddlers, children	Nervous system	Decrements in intelligence quotient Lead has several MOAs. Lead mimics calcium and disrupts calcium homeostasis, which affects cell signaling pathways (ATSDR 2007b). There is no threshold for effects for lead.	Chronic (various epidemiological studies)	SNC 2012, WHO 2011	Yes	NA	NA	-	-	-	-	-	North - unlikely Central - unlikely South - low and possible	Blood 30 days; bones 10-30 years (Rabinowitz 1991, as cited in WHO 2011)
							0.0013	teens adults	Cardiovascular system	Increased systolic blood pressure Lead has several MOAs. Hypertension caused by lead exposure is accompanied by depletion of nitric oxide, which plays an important role in regulating blood pressure (ATSDR 2007b). There is no threshold for effects for lead.	Chronic (various epidemiological studies)		No								North - unlikely Central - unlikely South - low and possible	
Manganese	1	0.01	Non. Car.[b]	NC	Group D	No	0.136	infants, toddlers	Nervous system	Parkinsonian-like neurotoxicity Manganese is a neurotoxin that can impair transport systems, enzyme activities and receptor functions; however, the exact MOA is unknown (ATSDR 2012b).	Chronic (epidemiological study; duration not reported)	Health Canada 2010	No	NA	NA	-	-	-	-	-	North - unlikely Central - unlikely South - low and possible	13 - 37 days (ATSDR 2012b)
							0.122	children														
							0.142	teens														
							0.156	adults														
Mercury (sediment and water contact pathways)	1	1	See IARC	Group 3	Group D	No	0.0003	all age groups	Kidney	Tubular lesions, proteinuria, immunoglobin G deposition in the glomeruli Exposure to mercury causes the formation of mercury-induced auto-immune glomerulonephritis, which is initiated by the production and deposition of immunoglobin G antibodies on the glomerular basement membrane (CCME 1999)	Subchronic; various studies (8-12 weeks, up to 60 days, 60 days)	Health Canada 2010	No	NA	NA	-	-	-	-	-	North - unlikely Central - unlikely South - low and possible	1 - 2 months (ATSDR 1999)
Methylmercury (fish consumption pathway)	1	NA	See IARC	Group 2B	Group C	No	0.0002	infants, toddlers, children <12 years, women of child-bearing age	Nervous system	Neurotoxicity, various forms of neurological damage (Health Canada 2007) Methylmercury disrupts microtubules and amino acid transport in neuronal cells (HSDB 2010b).	Chronic (epidemiological study; duration not reported)	Health Canada 2010	**Yes**	NA	NA	-	-	-	-	-	North - unlikely Central - unlikely South - low and possible	20 - 80 days (HSDB 2010b)
							0.00047	general adult population (teens and adults)	Nervous system	Neurotoxicity. Effects on fine motor function, attention, verbal learning and memory (Health Canada 2007) Methylmercury disrupts microtubules and amino acid transport in neuronal cells (HSDB 2010b).	Chronic (epidemiological study; duration not reported)											

Contaminant of Potential Concern	RAF(1)		Carcinogenic Classification				Non-carcinogenic							Carcinogenic							Likelihood of Exposures During a Sensitive Life Stage(8)	Whole Body Elimination Half Life
	Oral (unitless)	Dermal (unitless)	Health Canada(2)	IARC(3)	US EPA(4)	Assessed as a Carcinogen?	Oral RfD(5) (mg/kg/day)		Target Organ/System	Critical Effect & Mode of Action	Duration	Source	Developmental Toxicant?6	Oral SF $(mg/kg/day)^{-1}$	Dermal SF $(\mu g/cm^2/day)^{-1}$	Target Organ/System	Critical Effect & Mode of Action	Mutagenic?(7)	Duration	Source		
Vanadium	1	0.1	NC	NC	NC	No	0.005	all age groups	Immune system	Decreased hair cysteine content . Little information is available regarding the MOA of vanadium toxicity (ATSDR 2012c)	Chronic (2.5 years)	US EPA 1996, US EPA 2015b	No	NA	NA	-	-	-	-	-	North - unlikely Central - unlikely South - low and possible	Three phases in plasma: 15 minutes, 14 hours 8.5 days (RIVM 2009)
PCBs (Total)	1	0.14	inadequate data for evaluation of carcinogenicity to humans	Group 1	Group B2	No	0.00013	all age groups	Nervous system	Increased locomotor activity (Bowman et al. 1981) The RfD is a provisional TDI based on a NOAEL of 13 μg/kg/day PCB may alter subcellular distribution of protein kinase C isoforms, inducing neurotoxicity (Kodavanti 2005).	Chronic (65 to 102 weeks)	Health Canada 2010	Yes (dioxin-like PCBs)	NA	NA	-	-	-	-	-	North - unlikely Central - unlikely South - low and possible	0.02 years to infinity (ATSDR 2000)
Benzo(a)anthracene	1	0.148	NC	Group 2B	Group B2	**Yes**	NA	-	-	-	-	-	-	0.23	0.35	See B(a)P(d)					North - unlikely Central - unlikely South - low and possible	See B(a)P(d)
Benzo(a)pyrene	1	0.148	Group II	Group 1	Group B2	**Yes**	NA	-	-	-	-	-	-	2.3	3.5	Stomach	Gastric tumours (mostly squamous cell papillomas, with a few carcinomas). The Ames test (a biological assay used to determine the mutagenic potential of a chemical) indicates that benzo(a)pyrene is mutagenic when S-9 activated liver enzymes and TA1538 *Salmonella* are used. Metabolites of benzo(a)pyrene are considerably more mutagenic than the parent compound (Health Canada 1988).	Yes	Subchronic (110 days)	Health Canada 2010		30 hours (ATSDR 1995)
Benzo(b)fluoranthene	1	0.148	Group II	Group 2B	Group B2	**Yes**	NA	-	-	-	-	-	-	0.23	0.35	See B(a)P(d)						See B(a)P(d)
Benzo(g,h,i)perylene	1	0.148	NC	Group 3	Group D	**Yes**	NA	-	-	-	-	-	-	0.023	0.035	See B(a)P(d)						See B(a)P(d)
Benzo(j)fluoranthene	1	0.148	Group II	Group 2B	NC	**Yes**	NA	-	-	-	-	-	-	0.23	0.35	See B(a)P(d)						See B(a)P(d)
Benzo(k)fluoranthene	1	0.148	Group II	Group 2B	Group B2	**Yes**	NA	-	-	-	-	-	-	0.23	0.35	See B(a)P(d)						See B(a)P(d)
Chrysene	1	0.148	NC	Group 2B	Group B2	**Yes**	NA	-	-	-	-	-	-	0.023	0.035	See B(a)P(d)						See B(a)P(d)
Dibenzo(a,h)anthracene	1	0.148	NC	Group 2A	Group B2	**Yes**	NA	-	-	-	-	-	-	2.3	3.5	See B(a)P(d)						See B(a)P(d)
Indeno(1,2,3-c,d)pyrene	1	0.148	Group II	Group 2B	Group B2	**Yes**	NA	-	-	-	-	-	-	0.23	0.35	See B(a)P(d)						See B(a)P(d)

Chemical Properties for Dermal Exposure to Carcinogenic PAHs in Sediment	
Viable epidermal thickness factor (unitless)	0.2
Test animal skin area (cm^2)	6

Age Dependent Adjustment Factors for Exposure to Mutagenic Carcinogens (PAHs)	
Toddler	5
Child	3
Teen	2
Adult	1

Notes:
cm^2 = square centimetre; B(a)P = benzo(a)pyrene; COPC = contaminant of potential concern; IARC = International Agency for Research on Cancer; mg/cm^2 = milligram per square centimetre; mg/kg/day = milligram per kilogram per day; MOA = mode of action; NA = not applicable; NC = not classified; PAH = polycyclic aromatic hydrocarbon; PCBs = polychlorinated biphenyls; RAF = relative absorption factor; RfD = reference dose; SF = slope factor; US EPA = United States Environmental Protection Agency.
1 - In the absence of sediment dermal absorption factors, soil dermal absorption factors were applied in the dose estimation calculations for the sediment dermal contact pathway. The default oral RAF of 1 was used for oral exposure (Health Canada 2010). Soil dermal RAFs were obtained in order of preference from the following sources: Health Canada (2010), OMOE (2011), RAIS 2013. If soil dermal absorption factors were not available from these sources, a default value of 0.01 was assumed (OMOE 2011).
2 - Health Canada 2010
3 - IARC 2015
4 - US EPA 2015a
5 - Oral toxicity reference value adopted as dermal toxicity reference value if dermal toxicity reference value is not available.
6 - Classification as a developmental toxicant was obtained from Equilibrium Environmental Inc. (2009); however for the purposes of the risk refinement, all COPCs were assumed to be developmental toxicants (see Section 7.4 for more information).
7 - Health Canada 2013
8 - Refer to the report for a description of the exposure areas and assumptions about site use and receptors.
a - Not classified for the oral route. Classified as a Group I carcinogen via the inhalation route.
b - IOM 2001, as cited in Health Canada 2010, does not consider manganese carcinogenic to humans.
c - Group D for the oral route. Classified as Group A carcinogen via the inhalation route.
d - Carcinogenic PAHs are adjusted to their carcinogenic potency relative to benzo(a)pyrene using a potency equivalence factor (Health Canada 2010).

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Dose Equations used in the Risk Refinement

The following dose equations were taken from Health Canada (2010):

- incidental ingestion of suspended sediment (modified from the inadvertent ingestion of soil equation, as indicated in red font)
- dermal absorption from contaminated sediment (modified as indicated in red font from the dermal absorption from contaminated soil equation, for feet exposed to submerged bedded sediments)
- ingestion of contaminated water
- ingestion of fish

The following dose equations were taken from US EPA (2004):

- dermal contact with inorganics in water

References

Health Canada. 2010. Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on human health preliminary quantitative risk assessment (PQRA), Version 2.0. September 2010 (revised 2012). Contaminated Sites Division, Safe Environments Directorate.

US EPA (United States Environmental Protection Agency). 2004. Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Office of Superfund Remediation and Technology Innovation, US EPA, Washington, DC.

Incidental Ingestion of Suspended Sediment

$$\text{Dose (mg/kg BW/day)} = \frac{C_S \times IR_S \times RAF_{oral} \times \text{events/day} \times D1 \times D2 \times D3 \times D4}{BW \times LE}$$

Where:

C_S = concentration of contaminant in sediment (mg/kg)

IR_S = receptor suspended sediment ingestion rate (kg/hour)

RAF_{oral} = relative absorption factor from the gastrointestinal tract (unitless)

events/day = the number of sediment contact events per day

D1 = hours/event

D2 = days per week exposed/7 days

D3 = weeks per year exposed/52 weeks (evaluated on a chemical-specific basis)

D4 = total years exposed to site (for assessment of carcinogens only; evaluated on a chemical-specific basis)

BW = body weight (kg)

LE = life expectancy (years) (for assessment of carcinogens only)

Dermal Contact of Feet with Submerged Bedded Sediment

$$\text{Dose (mg/kg BW/day)} = \frac{(C_S \times SA_{feet} \times SL_{feet}) \times RAF_{derm} \times \text{events/day} \times D1 \times D2 \times D3 \times D4}{BW \times LE}$$

Where:

C_S = concentration of contaminant in sediment (mg/kg)

SA_{feet} = surface area of feet exposed for sediment loading (cm^2)

SL_{feet} = soil loading rate to exposed skin of feet (kg/cm^2-event)

RAF_{derm} = relative dermal absorption factor (unitless)

events/day = the number of sediment contact events per day

D1 = hours per day sediment is adhered to feet/24 hours

D2 = days per week exposed/7 days

D3 = weeks per year exposed/52 weeks (evaluated on a chemical-specific basis)

D4 = total years exposed to site (for assessment of carcinogens only)

BW = body weight (kg)

LE = life expectancy (years) (for assessment of carcinogens only)

Incidental Ingestion of Contaminated Surface Water

$$\text{Dose (mg/kg bw/day)} = \frac{Cw \times IRw \times RAF_{oral} \times D2 \times D3 \times D4}{BW \times LE}$$

Where:

Cw = concentration of contaminant in surface water (mg/L)

IRw = receptor incidental water intake rate (L/d)

RAF_{oral} = relative absorption factor from the gastrointestinal tract (unitless)

D2 = days per week exposed/7 days

D3 = weeks per year exposed/52 weeks (evaluated on a chemical-specific basis)

D4 = total years exposed to site (to be employed for assessment of carcinogens only)

BW = body weight (kg)

LE = life expectancy (years) (for assessment of carcinogens only)

Ingestion of Fish

$$\text{Dose (mg/kg BW/day)} = \frac{C_{fish} \times IR_{fish} \times RAF_{oral} \times D1 \times D2 \times D3}{BW \times LE}$$

Where:
C_{fish} = concentration of contaminant in fish (mg/kg)
IR_{fish} = receptor fish ingestion rate (kg/meal)
RAF_{oral} = relative absorption factor from the gastrointestinal tract (unitless); assumed to be 100%
D1 = meals per week
(conversion factor of 7 days/week)
D2 = weeks per year during which consumption of fish will occur (evaluated on a chemical-specific basis)
D3 = total years exposed to site (to be employed for assessment of carcinogens only)
BW = body weight (kg)
LE = life expectancy (years) (for assessment of carcinogens only)

Dermal Contact with Surface Water

$$DR_{DC} \text{ (mg/kg BW/day)} = \frac{SA \times DA_{event} \times D1 \times D2 \times D3}{BW \times LE}$$

Where:
DR_{DC} = dose rate from dermal contact with COPC in surface water (mg/kg BW/day)
SA = skin surface area available for dermal contact (cm^2)
DA_{event} = absorbed dose per event (mg/cm^2-event)
D1= days per week exposed / 7 days
D2 = weeks per year exposed/52 weeks (evaluated on a chemical-specific basis)
D3 = total years exposed to site (for carcinogens only)
BW = body weight (kg)
LE = life expectancy (years) (for carcinogens only)

Equations Needed to Calculate DA_{event} for Dermal Contact with Surface Water Pathway

Dermal Absorbed Dose (DA event) for Inorganic Substances in Surface Water

$$DA_{event} = Kp \times C_w \times t_{event}$$

Where:
DA_{event} = absorbed dose per event (mg/cm^2-event)
Kp = dermal permeability coefficient of the compound in water (cm/hour); chemical specific
C_w = chemical concentration in water (mg/cm^3); conversion factor of 1000 to convert mg/L to mg/cm^3
t_{event} = event duration (hours/event)

Lifetime Average Daily Dose (LADD) of PAHs (Sediment Dermal Contact)

$$\text{LADD } (\mu g/cm^2/day) = \frac{C_S \times SA_{feet} \times SL_{feet} \times RAF_{derm} \times ETF \times events/day \times D1 \times D2 \times D3 \times D4 \times CF}{SA_{test} \times LE}$$

Where:
C_S = concentration of contaminant in sediment (mg/kg)
SA_{feet} = surface area of feet exposed for sediment loading (cm^2)
SL_{feet} = soil loading rate to exposed skin of feet (kg/cm^2-event)
RAF_{derm} = relative dermal absorption factor (unitless)
ETF = epidermal thickness factor (0.2) based on Knafla et al. 2011 (unitless)
events/day = the number of sediment contact events per day
D1 = hours per day sediment is adhered to feet/24 hours
D2 = days per week exposed/7 days
D3 = weeks per year exposed/52 weeks (evaluated on a chemical-specific basis)
D4 = total years exposed to site (for assessment of carcinogens only)
CF = conversion factor 1000 µg/mg
SA_{test} = skin surface area of test animal
LE = life expectancy (years) (for assessment of carcinogens only)

The LADD of PAHs for short-term exposure to mutagenic carcinogens is adjusted by the following age-dependent adjustment factors (ADAFs; as per Health Canada 2013):

Receptor	ADAF
Toddler	5
Child	3
Teen	2
Adult	1

Sample Calculations - Non-cancer Exposure

Incidental Ingestion of Suspended Sediment

$$\text{Dose (mg/kg BW/day)} = \frac{C_S \times IR_S \times RAF_{oral} \times \text{events/day} \times D1 \times D2 \times D3 \times D4}{BW \times LE}$$

Where:
C_S = concentration of contaminant in sediment (mg/kg)
IR_S = receptor suspended sediment ingestion rate (kg/hour)
RAF_{oral} = relative absorption factor from the gastrointestinal tract (unitless)
Events/day
D1 = hours/event
D2 = days per week exposed/7 days
D3 = weeks per year exposed/52 weeks (evaluated on a chemical-specific basis)
D4 = total years exposed to site (for assessment of carcinogens only; evaluated on a chemical-specific basis)
BW = body weight (kg)
LE = life expectancy (years) (for assessment of carcinogens only)

Dose Estimate for Toddler Exposed to Arsenic in Western KIH Exposure Area - Central

$$\text{Dose} = \frac{67.5\ \text{(mg/kg)} \times 0.0000077\ \text{(kg/hour)} \times 1 \times 1\ \text{(event/day)} \times 1\ \text{(hour/event)} \times 1\ \text{(day/week)} / 7\ \text{(day/week)}}{16.5\ \text{(kg)}}$$

Dose = 4.50×10^{-6} (mg/kg BW/day)

Dermal Contact of Feet with Submerged Bedded Sediment

$$\text{Dose (mg/kg BW/day)} = \frac{(C_S \times SA_{feet} \times SL_{feet}) \times RAF_{derm} \times \text{event/day} \times D1 \times D2 \times D3 \times D4}{BW \times LE}$$

Where:
C_S = concentration of contaminant in sediment (mg/kg)
SA_{feet} = surface area of feet exposed for sediment loading (cm^2)
SL_{feet} = soil loading rate to exposed skin of feet (kg/cm^2-event)
RAF_{derm} = relative dermal absorption factor (unitless)
events/day = the number of sediment contact events per day
D1 = hours per day sediment is adhered to feet/24 hours
D2 = days per week exposed/7 days
D3 = weeks per year exposed/52 weeks (evaluated on a chemical-specific basis)
D4 = total years exposed to site (for assessment of carcinogens only)
BW = body weight (kg)
LE = life expectancy (years) (for assessment of carcinogens only)

Dose Estimate for Toddler Exposed to Arsenic in Western KIH Exposure Area - Central

$$\text{Dose} = \frac{67.5\ \text{(mg/kg)} \times 430\ (cm^2) \times 0.0000067\ (kg/cm^2\text{-event}) \times 0.03 \times 1\ \text{(event/day)} \times 2\ \text{(hour/day)} / 24\ \text{(hours/day)} \times 1\ \text{(day/week)} / 7\ \text{(day/week)}}{16.5\ \text{(kg)}}$$

Dose = 4.21×10^{-6} (mg/kg BW/day)

Sample Calculations - Non-cancer Exposure

Incidental Ingestion of Contaminated Surface Water

$$\text{Dose (mg/kg bw/day)} = \frac{C_w \times IR_w \times RAF_{oral} \times D2 \times D3 \times D4}{BW \times LE}$$

Where:

C_w = concentration of contaminant in surface water (mg/L)

IR_w = receptor incidental water intake rate (L/day)

RAF_{oral} = relative absorption factor from the gastrointestinal tract (unitless)

D2 = days per week exposed/7 days

D3 = weeks per year exposed/52 weeks (evaluated on a chemical-specific basis)

D4 = total years exposed to site (to be employed for assessment of carcinogens only)

BW = body weight (kg)

LE = life expectancy (years) (for assessment of carcinogens only)

Dose Estimate for Toddler Exposed to Arsenic in Western KIH Exposure Area - Central

$$\text{Dose} = \frac{0.0015\ \text{(mg/L)} \times 0.05\ \text{(L/day)} \times 1 \times 1\ \text{(day/week)} / 7\ \text{(day/week)}}{16.5\ \text{(kg)}}$$

Dose = 6.49×10^{-7} (mg/kg BW/day)

Ingestion of Fish

$$\text{Dose (mg/kg BW/day)} = \frac{C_{fish} \times IR_{fish} \times RAF_{oral} \times D1 \times D2 \times D3}{BW \times LE}$$

Where:

C_{fish} = concentration of contaminant in fish (mg/kg)

IR_{fish} = receptor fish ingestion rate (kg/meal)

RAF_{oral} = relative absorption factor from the gastrointestinal tract (unitless); assumed to be 100%

D1 = meals per week

(conversion factor of 7 days/week)

D2 = weeks per year during which consumption of fish will occur (evaluated on a chemical-specific basis)

D3 = total years exposed to site (to be employed for assessment of carcinogens only)

BW = body weight (kg)

LE = life expectancy (years) (for assessment of carcinogens only)

Dose Estimate for Toddler Exposed to Arsenic in Western KIH Exposure Area - Central

$$\text{Dose} = \frac{0.005\ \text{(mg/kg)} \times 0.075\ \text{(kg/meal)} \times 1 \times 1\ \text{(meal/week)} / 7\ \text{(day/week)}}{16.5\ \text{(kg)}}$$

Dose = 3.25×10^{-6} (mg/kg BW/day)

Dermal Contact with Surface Water

$$DR_{DC}\ \text{(mg/kg BW/day)} = \frac{SA \times DA_{event} \times D1 \times D2 \times D3}{BW \times LE}$$

Where:

Sample Calculations - Non-cancer Exposure

DR_{DC} = dose rate from dermal contact with COPC in surface water (mg/kg BW/day)
SA = skin surface area available for dermal contact (cm^2)
DA_{event} = absorbed dose per event (mg/cm^2-event) (equation below)
D1= days per week exposed / 7 days
D2 = weeks per year exposed/52 weeks (evaluated on a chemical-specific basis)
D3= total years exposed to site (for carcinogens only)
BW = body weight (kg)
LE = life expectancy (year) (for carcinogens only)

Dermal Absorbed Dose (DA_{event}) for Inorganic Substances in Surface Water

$DA_{event} = Kp \times C_w \times t_{event}$

Where:
DA_{event} = absorbed dose per event (mg/cm^2-event)
Kp = dermal permeability coefficient of the compound in water (cm/hour); chemical specific
C_w = chemical concentration in water (mg/cm^3); conversion factor of 1000 to convert mg/L to mg/cm^3
t_{event} = event duration (hours/event)

Dose Estimate for Toddler Exposed to Arsenic in Western KIH Exposure Area - Central

DA_{event} = 0.001 (cm/hour) x 0.0015 (mg/L) x 0.001 (L/cm^3) x 1 (hour/event)

DA_{event} = 1.5×10^{-9} (mg/cm^2/event)

$$\text{Dose} = \frac{6130\ (cm^2) \times 1.5\times10^{-9}\ (mg/cm^2/event) \times 1\ (day/week)\ /\ 7\ (day/week)}{16.5\ (kg)}$$

Dose = 7.696×10^{-8} (mg/kg BW/day)

Hazard Quotient

$$HQ = \frac{\text{Dose Estimate}}{\text{RfD}}$$

Where:
HQ = hazard quotient (unitless)
Dose Estimate = estimated dose for a particular pathway (mg/kg BW/day)
RfD = reference dose (mg/kg/day)

Risk Estimate for Toddler Exposed to Arsenic for the Incidental Ingestion of Sediment Pathway in Western KIH Exposure Area - Central

$$HQ = \frac{4.50\times10^{-6}\ (mg/kg\ BW/day)}{0.0003\ (mg/kg/day)}$$

HQ = 0.015

Sample Calculations - Cancer Exposure

Incidental Ingestion of Suspended Sediment

$$\text{Dose (mg/kg BW/day)} = \frac{C_S \times IR_S \times RAF_{oral} \times \text{events/day} \times D1 \times D2 \times D3 \times D4}{BW \times LE}$$

Where:
C_S = concentration of contaminant in sediment (mg/kg)
IR_S = receptor suspended sediment ingestion rate (kg/hour)
RAF_{oral} = relative absorption factor from the gastrointestinal tract (unitless)
Events/day
D1 = hours/event
D2 = days per week exposed/7 days
D3 = weeks per year exposed/52 weeks (evaluated on a chemical-specific basis)
D4 = total years exposed to site (for assessment of carcinogens only; evaluated on a chemical-specific basis)
BW = body weight (kg)
LE = life expectancy (years) (for assessment of carcinogens only)

Dose Estimate for Adult Exposed to Arsenic in Western KIH Exposure Area - Central

$$\text{Dose} = \frac{67.5\text{ (mg/kg)} \times 0.0000077\text{ (kg/hour)} \times 1 \times 1\text{ (event/day)} \times 1\text{ (hour/event)} \times 1\text{ (day/week)} / 7\text{ (day/week)} \times 17\text{ (week/year)} / 52\text{ (week/year)} \times 60\text{ (years)}}{70.7\text{ (kg)} \times 80\text{ (years)}}$$

Dose = 2.58×10^{-7} (mg/kg BW/day)

Dermal Contact of Feet with Submerged Bedded Sediment

$$\text{Dose (mg/kg BW/day)} = \frac{(C_S \times SA_{feet} \times SL_{feet}) \times RAF_{derm} \times \text{event/day} \times D1 \times D2 \times D3 \times D4}{BW \times LE}$$

Where:
C_S = concentration of contaminant in sediment (mg/kg)
SA_{feet} = surface area of feet exposed for sediment loading (cm^2)
SL_{feet} = soil loading rate to exposed skin of feet (kg/cm^2-event)
RAF_{derm} = relative dermal absorption factor (unitless)
events/day = the number of sediment contact events per day
D1 = hours per day sediment is adhered to feet/24 hours
D2 = days per week exposed/7 days
D3 = weeks per year exposed/52 weeks (evaluated on a chemical-specific basis)
D4 = total years exposed to site (for assessment of carcinogens only)
BW = body weight (kg)
LE = life expectancy (years) (for assessment of carcinogens only)

Dose Estimate for Adult Exposed to Arsenic in Western KIH Exposure Area - Central

$$\text{Dose} = \frac{67.5\text{ (mg/kg)} \times 1200\text{ (cm}^2\text{)} \times 0.0000067\text{ (kg/cm}^2\text{-event)} \times 0.03 \times 1\text{ (event/day)} \times 2\text{ (hour/day)} / 24\text{ (hours/day)} \times 1\text{ (day/week)} / 7\text{ (day/week)} \times 17\text{ (week/year)} / 52\text{ (week/year)} \times 60\text{ (years)}}{70.7\text{ (kg)} \times 80\text{ (years)}}$$

Dose = 6.72×10^{-7} (mg/kg BW/day)

Sample Calculations - Cancer Exposure

Incidental Ingestion of Contaminated Surface Water

$$\text{Dose (mg/kg bw/day)} = \frac{C_w \times IR_w \times RAF_{oral} \times D2 \times D3 \times D4}{BW \times LE}$$

Where:
C_w = concentration of contaminant in surface water (mg/L)
IR_w = receptor incidental water intake rate (L/day)
RAF_{oral} = relative absorption factor from the gastrointestinal tract (unitless)
D2 = days per week exposed/7 days
D3 = weeks per year exposed/52 weeks (evaluated on a chemical-specific basis)
D4 = total years exposed to site (to be employed for assessment of carcinogens only)
BW = body weight (kg)
LE = life expectancy (years) (for assessment of carcinogens only)

Dose Estimate for Adult Exposed to Arsenic in Western KIH Exposure Area - Central

$$\text{Dose} = \frac{0.0015\text{ (mg/L) x 0.05 (L/day) x 1 x 1 (day/week) / 7 (day/week) x 17 (week/year) / 52 (week/year) x 60 (years)}}{70.7\text{ (kg) x 80 (years)}}$$

Dose = 3.72×10^{-8} (mg/kg BW/day)

Ingestion of Fish

$$\text{Dose (mg/kg BW/day)} = \frac{C_{fish} \times IR_{fish} \times RAF_{oral} \times D1 \times D2 \times D3}{BW \times LE}$$

Where:
C_{fish} = concentration of contaminant in fish (mg/kg)
IR_{fish} = receptor fish ingestion rate (kg/meal)
RAF_{oral} = relative absorption factor from the gastrointestinal tract (unitless); assumed to be 100%
D1 = meals per week
(conversion factor of 7 days/week)
D2 = weeks per year during which consumption of fish will occur (evaluated on a chemical-specific basis)
D3 = total years exposed to site (to be employed for assessment of carcinogens only)
BW = body weight (kg)
LE = life expectancy (years) (for assessment of carcinogens only)

Dose Estimate for Adult Exposed to Arsenic in Western KIH Exposure Area - Central

$$\text{Dose} = \frac{0.005\text{ (mg/kg) x 0.227 (kg/meal) x 1 x 1.25 (meal/week) / 7 (day/week) x 52 (week/year) / 52 (week/year) x 60 (years)}}{70.7\text{ (kg) x 80 (years)}}$$

Dose = 2.15×10^{-6} (mg/kg BW/day)

Dermal Contact with Surface Water

$$DR_{DC}\text{ (mg/kg BW/day)} = \frac{SA \times DA_{event} \times D1 \times D2 \times D3}{BW \times LE}$$

Where:
DR_{DC} = dose rate from dermal contact with COPC in surface water (mg/kg BW/day)
SA = skin surface area available for dermal contact (cm^2)
DA_{event} = absorbed dose per event (mg/cm^2-event) (equation below)
D1= days per week exposed / 7 days
D2 = weeks per year exposed/52 weeks (evaluated on a chemical-specific basis)
D3= total years exposed to site (for carcinogens only)
BW = body weight (kg)
LE = life expectancy (year) (for carcinogens only)

Sample Calculations - Cancer Exposure

Dermal Absorbed Dose (DA_{event}) for Inorganic Substances in Surface Water

$DA_{event} = Kp \times C_w \times t_{event}$

Where:
DA_{event} = absorbed dose per event (mg/cm^2-event)
Kp = dermal permeability coefficient of the compound in water (cm/hour); chemical specific
C_w = chemical concentration in water (mg/cm^3); conversion factor of 1000 to convert mg/L to mg/cm^3
t_{event} = event duration (hours/event)

Dose Estimate for Adult Exposed to Arsenic in Western KIH Exposure Area - Central

DA_{event} = 0.001 (cm/hour) x 0.0015 (mg/L) x 0.001 (L/cm^3) x 1 (hour/event)

DA_{event} = 1.5x10^{-9} (mg/cm^2/event)

$$\text{Dose} = \frac{17640\ (\text{cm}^2) \times 1.5\text{x}10^{-9}\ (\text{mg/cm}^2\text{/event}) \times 1\ (\text{day/week}) / 7\ (\text{day/week}) \times 17\ (\text{week/year}) / 52\ (\text{week/year}) \times 60\ (\text{years})}{70.7\ (\text{kg}) \times 80\ (\text{years})}$$

Dose = 1.31x10^{-8} (mg/kg BW/day)

Incremental Lifetime Cancer Risk

ILCR = Dose Estimate x SF

Where:
ILCR = incremental lifetime cancer risk (unitless)
Dose Estimate = estimated dose for a particular pathway (mg/kg BW/day)
SF = slope factor (mg/kg/day)$^{-1}$

Risk Estimate for Adult Exposed to Arsenic for the Incidental Ingestion of Sediment Pathway in Western KIH Exposure Area - Central

ILCR = 2.58x10^{-7} (mg/kg BW/day) x 1.8 (mg/kg/day)$^{-1}$

ILCR = 4.6x10^{-7}

Lifetime Average Daily Dose (LADD) of PAHs (Sediment Dermal Contact)

$$LADD = \frac{C_S \times SA_{feet} \times SL_{feet} \times RAF_{derm} \times ETF \times events/day \times D1 \times D2 \times D3 \times D4 \times CF}{SA_{test} \times LE}$$

Where:
LADD = lifetime avergage daily dose; dose received during a lifestage averaged over a lifetime (µg/cm^2/day)
C_S = concentration of contaminant in sediment (mg/kg)
SA_{feet} = surface area of feet exposed for sediment loading (cm^2)
SL_{feet} = soil loading rate to exposed skin of feet (kg/cm^2-event)
RAF_{derm} = relative dermal absorption factor (unitless)
ETF = epidermal thickness factor (unitless)
events/day = the number of sediment contact events per day
D1 = hours per day sediment is adhered to feet/24 hours
D2 = days per week exposed/7 days
D3 = weeks per year exposed/52 weeks (evaluated on a chemical-specific basis)
D4 = total years exposed to site (for assessment of carcinogens only)
CF = conversion factor 1000 µg/mg
SA_{test} = skin surface area of test animal
LE = life expectancy (years) (for assessment of carcinogens only)

Sample Calculations - Cancer Exposure

Dose Estimate for Toddler Exposed to Benzo(a)pyrene in Western KIH Exposure Area - Central

$$\text{LADD} = \frac{1.44\ (\text{mg/kg}) \times 430\ (\text{cm}^2) \times 0.0000067\ (\text{kg/cm}^2\text{-event}) \times 0.148 \times 0.2 \times 1\ (\text{event/day}) \times 2\ (\text{hours/day}) / 24\ (\text{hours/day}) \times 1\ (\text{day/week}) / 7\ (\text{day/week}) \times 17\ (\text{weeks/year}) / 52\ (\text{weeks/year}) \times 4.5\ (\text{years}) \times 1000\ (\mu\text{g/mg})}{6\ (\text{cm}^2) \times 80\ (\text{years})}$$

LADD = $4.48\text{x}10^{-6}$ (μg/cm^2/day)

Lifetime Average Daily Dose Short-term Incremental Lifetime Cancer Risk

ILCR = Σ(LADD x SF x ADAF)

Where:
LADD = lifetime avergage daily dose; dose received during a lifestage averaged over a lifetime (μg/cm^2/day)
SF = slope factor $(\text{mg/kg/day})^{-1}$
ADAF = age-dependent adjustment factor for life stage (unitless)

Risk Estimate for Toddler Exposed to Benzo(a)pyrene in Western KIH Exposure Area - Central

ILCR = $4.48\text{x}10^{-6}$ (μg/cm^2/day) x 3.5 $(\text{mg/kg/day})^{-1}$ x 5

ILCR = $7.8\text{x}10^{-5}$

APPENDIX D

Documentation of FCSAP Expert Support Feedback

Fisheries and Oceans Canada | Pêches et Océans Canada

Central and Arctic Region | Région du Centre et de l'Arctique
Fisheries and Oceans Canada | Pêches et Océans Canada
501 University Crescent | 501 University Crescent
Winnipeg, Manitoba R3T 2N6 | Winnipeg (Manitoba) R3T 2N6

Your file *Votre réference*

February 24, 2015 **Sent Via Email**

Jennifer Hughes
Supervisor Environmental Assessment
Transport Canada
Environment and Engineering
4900 Yonge Street
North York, Ontario M2N 6A5

Brent O'Rae
Contaminated Sites Ecologist
Parks Canada
635-8th Ave. South West, Suite 1550
Calgary, Alberta T2P 3M3

Dear Ms. Hughes and Mr O'Rae,

Subject: Review of Golder's responses to Department of Fisheries and Oceans, June 2014 Comments on the Kingston Inner Harbour Sediment Assessments.

Fisheries and Oceans Canada has reviewed Golder's responses dated January 12, 2015 in the technical Memorandum entitled "*Draft Response to the FCSAP Expert Support Comments on Kingston Inner Harbour 2014 Reporting Package*," to Fisheries and Oceans comments on the June 2014 RMC-ESG report entitled "*Application of the Canadian-Ontario Decision-Making Framework for Contaminated Sediments in Kingston Inner Harbour*," dated February, 2014, and on Golder's memorandum entitled "*Review of Revised RMC Reporting on Kingston Inner Harbour Sediment*," date March, 2014. Please find our comments below for your consideration. This review was completed as part of our role as an Expert Support Department under the Federal Contaminated Site Program (FCSAP).

Please feel free to contact me via email (Tara.Bortoluzzi@dfo-mpo.gc.ca) or phone (204 984-8908) if you have any questions.

Sincerely,

T Bortoluzzi

Tara Bortoluzzi
Fisheries Biologist
FCSAP Expert Support

.../2

Canada

cc: Maria Petrou, Rui Fonseca and Anita Wong, Environment Canada
Heather Jones-Otazo, Viktors Kulnieks and Angela Li-Muller, Health Canada

Site: Kingston Inner Harbour
Report Title: Draft Response to the FCSAP Expert Support Comments on Kingston Inner Harbour 2014 Reporting Package
Report Date: January 12, 2015
Prepared By: Golder Associates Ltd.
Prepared for: Transport Canada and Parks Canada
Date Reviewed: February 24, 2016
Reviewed by: Tara Bortoluzzi, Fisheries and Oceans Canada, Expert Support

DFO Follow-up Comments on Golder Responses dated January 12, 2015

Comment Number	**DFOs Original Comments (June, 2014)**	**Comments from Golder Associates Technical Memorandum**	**DFOs Follow-up Comments**
1	n/a	Divison of comments: *Category 4 – Topic raised is beyond the scope of the risk refinement (i.e., feedback is relevant but relates to future stages of site management), or relates to RMC-ESG deliverable details not within Golder's scope or control.*	DFO requests further clarification regarding category 4 as it pertains to the division of comments given by Golder Associates. Further clarifications on what constitutes a comment or topic being beyond the scope of the risk refinement or beyond Golder's scope or control should be explained.
2 (DFO-2014-001)	The Area(s) of Potential Environmental Concern (APECs) in KIH is/are not clearly defined in the report. None of the maps included in the report clearly identify the site boundaries. It is unclear whether the APEC(s) referred to in this report encompasses all/part of the Orchard Street Marsh, the Parks Canada water lot, and/or the Transport Canada water lot. A clear picture of the Area(s) of Potential Environmental Concern is needed.	*We agree that defining areas of concern is an important aspect on the risk characterization. We intend to develop revised management zones that combine consideration of property boundaries (Transport Canada, Parks Canada, and others) and that also define transitions in the distribution of exposure and effects data. Our previous reports (PQRA and DQRA) applied a similar breakdown of sediments into management areas; however, a substantial amount of risk assessment information has been obtained since that time, such that reconfiguring the boundaries is warranted. The size and shape of the management units will also consider factors such as distance from shoreline, simplicity for*	Satisfactory response. Please note that the APECs are defined as a portion of a site where contamination is suspected or confirmed. As an APEC can include many COPCs, it is important to ensure that all possible COPCs are included. Proper testing and identification of COPC's within an APEC can then be delineated.

		defining potential dredge cuts, and the degree of overlap among contaminant distributions for key constituents. The use of spatially defined APECs does not constrain the development of risk assessment outcomes for receptors that cross spatial boundaries. Rather, the results for management units can be aggregated into larger areas as appropriate, incorporating knowledge of the relative use of each unit (e.g., proximity to shoreline, habitat preferences, etc.).	
3 (DFO-2014-002)	Fisheries and Oceans Canada is listed as a member of the Cataraqui River Stakeholder Group (CRSG; page iii, paragraph 3). Please note the DFO FCSAP Expert Support teams involvement in KIH is to support and provide technical advice to federal site custodians under the FCSAP framework (i.e. in this case Parks Canada and Transport Canada). DFO FCSAP ES is not a key stakeholder nor is it a member of the CRSG.	*This comment, and several similar comments raised by Expert Support, relate to the comments made in the RMC-ESG deliverable concerning the degree of acceptance or endorsement of risk assessment approaches and conclusions. We understand that there are some technical areas for which there has not been consensus or endorsement by the Expert Support departments. Our approach will be to incorporate the technical input of the Expert Support depatments, also acknowledging previous comments from these departments based on earlier draft versions of the RMC-ESG reporting package. It is not our intention to engage the Cataraqui River Stakeholder Group until these technical refinements are complete.*	DFO notes that Golder's response is a category 4 comment. Please note that our previous comments where we state that DFO expert support under FCSAP is *not* a member of the Cataraqui River Stakeholder Group (CRSG). Please revise accordingly.

4 (DFO-2014-003)	The report states "the five chapters in this report summarize everything that is known about the Harbour" (page IV, paragraph 3). This statement is misleading as there are other available studies, data and information regarding KIH that were not included in this report. Please revise this statement.	*We agree that there are other sources of information that provide important contributions to the understanding of risk in the Harbour. The 2014 RMC deliverable attempted to synthesize previous studies with additional information collected on behalf of the custodial departments (Parks Canada, Transport Canada). However, due to the iterative nature of the investigations, additional information continued to become available as the RMC-ESG deliverable was being refined. Some of this information, such as localized presence of elevated PAH concentrations in some sediments adjacent to Anglin Bay, will have a meaningful influence on the overall risk characterization of harbour sediments. At a broader level, there are related statements made in the RMC-ESG reporting package that suggest that the technical investigation was complete by 2013 and that the only remaining steps entailed remedial options evaluation. We do not believe that these statements (opinions) were justified because the investigations have revealed important information on both exposure and effects that rendered final decision-making for sediments in the KIH to be premature.*	DFO notes that Golder's response is a category 4 comment. Although Golder has accepted DFOs original comment, DFO would like to restate that the rationale behind DFOs comment was to indicate that the summary previously provided did not include *all* known information. A more appropriate statement might be "*the five chapters in this report summarize information known about the Harbour*."

5 (DFO-2014-004)	The report notes that "Sediment transport and deposition patterns within the KIH are not well understood but are probably complex, given the hydrological flow constraints and shallow depths. Sediment resuspension from wind and wave action, boating activities and flow patterns appears to be important in redistributing sediments within the harbour" (page III-2, paragraph 4). Before proceeding with any plans for remediation work, the study would greatly benefit from sediment stability assessment to evaluate and better understand critical shear stress for erosion of various areas of contaminated sediments, as well as modeling and prediction of the expected shear stress from wind and water flow driven currents and vessels.	*We agree that sediment transport and deposition are an important aspect of the overall project, and have previously identified this issue to site custodians. In particular, the effectiveness and permanence of the overall remedy will be influenced by the redistribution of surface sediments from waves, currents, and mechanical disturbance. We are concerned that the Chapter V recommendations in the RMC-ESG reporting package, particularly concerning the use of narrow buffer zones for management of risks attributable to wading and swimming exposure pathways, do not consider the potential for recontamination from adjacent areas. That said, there is still value is characterizing present-day risks to the various receptor groups, including those that migrate across area boundaries, and then conducting a separate assessment of how various remediation tools will be influenced by sediment stability. For example, if a sediment unit is determined to require remediation, the potential for recontamination will be different using dredging, dredging with backfilling, capping, or enhanced natural recovery. At this stage, we believe that decision-making is best informed by conveying present-day risks for various receptors and pathways, focussing on current near-surface conditions. Following the Canada Ontario Framework, this approach aligns with Decision Point 4; at this stage "definitive determinations are possible in some cases with the proviso that sediment stability may still need to be assessed (Step 7); in other cases, further assessment is needed, but can be guided by the results of this data integration."*	Satisfactory response. However, please note that as discussed with Jennifer Hughes (Transport Canada) via email February 25, 2015, DFO is available to assist financially with a study examining sediment stability assessment. Jennifer noted that 'The current workplan does call for a sediment stability assessment to follow, and this will be confirmed once the RA refinement work is concluded. All work for 2015/16, however, would be subject to budget delegation/approval which has not yet been received by TC.'

		The assessment of sediment stability would be combined with assessment of contamination at depth, where applicable. Step 7 of the COA Framework considers whether, under unusual but possible natural or human-related circumstances, these deeper sediments may be uncovered, and also whether deposits from adjacent areas will influence long-term exposures at the sediment surface. Therefore, although we agree that sediment stability assessment will ultimately be important for site management, such studies can be conducted following the risk assessment refinement that is currently underway. The results of the risk refinement will help inform which sediment units are of greatest priority for the evaluation of stability.	
6 (DFO-2014-005)	The sediment maps include data from 1991 and 2008 (page II-2 and Table II-1). Given the harbour is shallow; the sediments are subject to frequent movement, resuspension, and disturbance. Further some of the sources of contamination have been migrated, for example the study by Benoit and Burniston (2010), referenced in the report, notes that dredging activities previously occurred near Emma Martin Park in 2004-2005 to address PCB contamination. Any data used to characterize contamination characteristics in KIH should be representative of current conditions, and data collected prior to dredging or	*The inclusion of data from 1991 is specific to the RMC-ESG deliverable. However, Golder has also developed a database on surface sediment chemistry information in GIS format, which was used to create surfaces presented in the PQRA and DQRA. This database includes historical investigations plus recent supplemental studies, such as data from toxicity and chemistry studies conducted in the Parks Canada water lot in November 2012 and sediment quality data from southwest KIH collected for Transport Canada in September 2013. In preparing surfaces of sediment quality conditions, we have combined data sets from multiple sampling rounds, and previously (in PQRA and DQRA) used a cutoff of 2003*	DFO recommends that a similar explanation of why data older than 5 years is included within the risk assessment should be included in the report.

	remediation activities should not be used. However, results of these dredging activities, or any other dredging, remediation, or alternation in KIH should also be discussed in the report.	*to distinguish potentially outdated information from data considered to reflect current conditions near the sediment surface. Although we believe that the selection of 2003 represents a reasonable compromise between the considerations of temporal representativeness of data and degree of spatial coverage, we also understand that the dredging program along the western shoreline in 2004-2005 is a special case warranting careful consideration of the representativeness of sediment data. As part of the risk refinement, we will review the samples collected between 2003 and 2005 and will exclude any data points that would represent sediment pockets removed during that program. Sediments sampled between 2003 and 2005 that are beyond the footprint of remediation will be retained.*	
7 (DFO-2014-006)	The inclusion of site map(s) are needed to better illustrate the locations of sediment sampling sites in the 'Contaminated' APEC and 'Reference' sites used in the data analysis, tables and figures.	*Although this comment was directed to the RMC-ESG 2014 reporting package, it has relevance to the forthcoming risk refinement deliverable. We intend to convey sediment quality data in relation to both legal lot boundaries and management units (i.e., APECs). Some of the figures will emphasize conditions downstream of Belle Island (i.e., the area defined by RMC-ESG to be the "contaminated" area). We are in agreement with RMC-ESG that the sediments north of Belle Island and the Transport Canada water lot generally provide a suitable reference condition for comparison with the downstream areas*	Satisfactory response.

8 (DFO-2014-007)	All the figures and tables should include the date(s) samples were collected.	*Although this comment was directed to the RMC-ESG 2014 reporting package, it has relevance to the forthcoming risk refinement deliverable. Our previous reports, such as the Transport Canada waterlot sediment investigation (March 27, 2014), included contamination distribution figures that labelled all individual stations with Sample IDs. However, due to the number of density of sampling points, it is not practical to also label sampling date or other details (such would not be legible). Instead, we can explore the use of coded symbols, font types, or other means of distinguishing sediment quality data from different years.*	Satisfactory response.
9 (DFO-2014-008)	The Boxplot Figures should include p- and r2 -values to indicate the statistical significance of the difference in the concentration of COPCs between 'Contaminated' and 'Reference' sites.	*Relates primarily to RMC-ESG reporting, although the comment is acknowledged in terms of providing details of any statistical comparisons between exposed and upstream reference conditions.*	Satisfactory response.

10 (DFO-2014-009)	The executive summary indicates the results of the sediment investigations show 'consistent evidence of ecological effects for benthic communities in the southern portion of the harbour" (executive summary, page ii); however this is not consistent with the overall results of the chapter which show mixed, inconclusive or no evidence of effects across KIH. For example the report states "The assessment of toxicity in the southwestern KIH is complicated by conflicting results between co-located sediment samples tested by Cantest and Environment Canada for some test locations" (page III-8, paragraph 1), and "Overall, the available studies indicate negligible toxicity for areas north of Belle Park and for the central and eastern portions of the southern KIH. There is mixed evidence for benthic invertebrate toxicity in the southwestern portion of the KIH" (page III-8, paragraph 3). The conclusions reached in this chapter are unclear and need revision.	*Although this comment was directed to the RMC-ESG 2014 reporting package, it has relevance to the forthcoming risk refinement deliverable. We agree that Chapters III and V present an unclear summary of the ecological significance of benthic community conditions, sometimes suggesting evidence of impact and at other times discounting results from the assessment of invertebrates. This confusion arises from two elements of the documentation. First, the lack of spatial specificity in the conclusions means that the narrative for benthic communities oversimplifies results that cover a wide range of conditions and findings. In this regard, we intend to use refined management zones to convey that benthic community results differ across the lower KIH, using a weight of evidence framework to distinguish between stations and zones indicating meaningful impairment from those that do not. Second, the RMC-ESG narratives have in some cases blurred the distinction between the scientific outcomes of the studies and the stakeholder consultations from June 2010. Although it may be appropriate to incorporate stakeholder input as part of the overall remedial options analysis, the presentation of risks to each receptor group must be conveyed transparently and objectively before any value-based assignments are made. The latter point has been confirmed in subsequent FCSAP Expert Support Comments.*	Satisfactory response.

11 (DFO-2014-010)	It is unclear why macrophytes and benthic invertebrates were excluded from the risk assessment. Toxicological data are available to assess the risk to these organisms. If these organisms are excluded from the risk assessment, clear rationale should be provided.	*We believe that the reviewer's confusion is related to the reporting structure in the RMC-ESG 2014 reporting package. RMC-ESG partitioned the evaluation of the lower trophic levels (benthic invertebrates and aquatic plants) from the evaluation of human health and wildlife (birds, mammals). Therefore these receptor groups were not excluded from the overall risk assessment package, but rather partitioned into two separate HHERA chapters. In some respects this approach makes sense because the types of tools applied in each chapter differ between these groups. For example, the human health and wildlife assessments rely on a hazard quotient approach (i.e., comparison of dose to toxicity reference value) whereas the benthic community assessment applies a weight-of-evidence analysis. The fish receptor group is more complicated because the bioaccumulation aspects are covered in Chapter III whereas the assessment of fish health is covered in Chapter IV. The RMC-ESG assessment considered both macrophytes (and cattails) and benthic invertebrates in Chapter III; the former were used primarily as an indicator of bioaccumulation/biomagnification potential. However, Chapter I of the RMC-ESG report also documents information on macrophyte community structure, including work by the Royal Military College documenting that communities did not appear to be related to sediment contamination. Overall, we believe that RMC-ESG have presented sufficient evidence that macrophytes can be excluded from consideration as a sensitive receptor group.*	Satisfactory response.

12 (DFO-2014-011)	While reptiles and amphibians were included in the Conceptual Site Model (CSM), they were not included in the final risk assessment. Several turtles, snakes and frogs were observed during a site visit to Kingston Inner Harbour on June 4th, 2013. Further the chapter notes that numerous reptiles and amphibians inhabit the APEC (page III-11 and III-12), and Chapter I (literature review) notes that "sixteen species of reptiles and amphibians have been observed in KIH," including species at risk (page III-21, paragraph 4). Amphibians and reptiles should be considered potentially sensitive receptors requiring further consideration in the risk assessment; If not additional rationale (other than a lack of toxicological information) should be provided as to why these receptors have not been further considered.	*The assessment of herptiles is challenging based on both the scarcity of toxicological information and the complexity of the exposures of these animals (i.e., combination of aquatic and terrestrial exposure that is linked strong to life stage). However, we agree that some evaluation of these receptors should be provided, even if the uncertainty is large relative to fish and benthic invertebrates. Our scope and schedule for the risk refinement does not allow for a site-specific toxicological evaluation; however, some information is available from the literature that would help to inform a qualitative or semi-quantitative assessment for these species. For example, sediment benchmarks for PCBs have been developed at other sites (e.g., Housatonic River MA). Information on the relative sensitivity of reptiles, invertebrates, and other organisms may also be available to provide insight on the degree of protection provided by SeQOs based on a limited representation of species. This information will be considered in the risk refinement document.*	Satisfactory reponse.

13 (DFO-2014-012)	Ecological Risk Assessment (Section III)] • While it is noted Chapter I (literature review) that aquatic species of risk (SARA) are found in KIH (page III-15, paragraph 1), no species at risk were evaluated in the risk assessment (i.e. fish, amphibians). Any species at risk that use or frequent KIH should be included in the risk assessment. If not additional rationale (other than a lack of toxicological information) should be provided as to why these receptors have not been further considered.	*The list of species of special concern mentioned in Chapter I includes the entire Kingston Inner Harbour, including areas north of Belle Island such as the Great Cataraqui Marsh that are designated as provincially significant wetlands. In contrast, the habitats south of Belle Island in the vicinity of former and current industrial and commercial land uses would have a subset of the species documented for the entire KIH. However, the point made concerning the need to describe risks to species of special concern is valid. We recommend refining the list of species of special concern to include only those identified in the lower portions of KIH (such as in the species inventory and ecological evaluation of the Orchard Street Marsh in 2008). Next, the risk assessment results for the receptors formally included in the RMC-ESG wildlife risk assessment can be evaluated for relevance to these additional species. By comparing the life history attributes (e.g., diet, home range, habitat preferences) some qualitative information on risk to species of special concern can be obtained. Furthermore, because the existing risk assessment results for wildlife have been developed based on assessment of risk to individuals (rather than populations or communities), the methods are transferable to assessment of listed species.*	Satisfactory response.

14 (DFO-2014-013)	The report notes that TRVs used for the fish tissue residue study were not appropriate for brown bullhead or other piscivorous fish (page III-37). Given the resultant uncertainties with this approach, COPC toxicity thresholds may need to be uniquely determined for each fish species and varying exposure pathways and site specific hazard quotients may need to be reconsidered	*The comments made by RMC-ESG regarding the perceived limitations of tissue-based TRVs for fish were intended to explain why observed effects in bottom fish might be possible even when observed tissue concentrations do not exceed literature-based benchmarks. Although there are some uncertainties with extrapolating benchmarks across species and habitats, there is a more fundamental issue here. The benchmarks considered by RMC-ESG considered only PCBs and a few metals/metalloids (arsenic, copper, lead, zinc, mercury) and only considered tissue-based benchmarks. Before speculating on the ecological relevance of these thresholds to bottom fish, it is necessary to consider other risk pathways not captured by this tissue screening. The most obvious oversight in this evaluation is PAH exposure to bottom fish, which is not captured by tissue-based screening (because PAHs are readily transformed into metabolites by teleost fish). Golder has conducted an evaluation ofsediment-based benchmarks for protection of bottom fish from various abnormalities, and has concluded that some areas of KIH exceed concentrations shown to elevate tumour prevalence at similar sites.To address the Export Support Comment, we agree that additional information is required to support the assessment of individual COPC risks to fish. Both tissue and sediment benchmarks can be considered as appropriate and used to support a weight of evidence for risks to fish. Rather than abandon the fish health pathway (i.e., Chapter V does not develop SeQOs for this pathway, opting instead to assume that remediation for other*	Satisfactory response.

		purposes will appropriately improve the environmental conditions), our approach will be to carry forward benchmarks for both tissue- and sediment-based benchmarks for the protection of fish health. The strengths and uncertainties of these evaluations can then be evaluated as part of the weight-of-evidence.	
15 (DFO-2014-014)	Deformities, lesions and tumors in brown bullheads were used as a measurement endpoint of fish health (page III-16, paragraph 5). The causes of these deformities were speculated to be a cause of the interaction of chemical mixtures within the sediments resulting in additive and/or synergistic effects (page III-35 to III-37). Other studies have shown that COPCs can interact in aquatic environments resulting in synergistic ecological effects. The report would benefit by further elaborating and including further literature references regarding their concerns of increased toxicity to fish from combined COPCs in KIH, particularly PAHs and other COPCs. Please see Gauthier et al. (2014) for recent references.	¡ *See response to comment DFO-2014-013. Although we agree that interactions among sediment-associated substances are possible, the discussion of physical abnormalities provided in Chapter IV and Chapter V does not, in our opinion, appropriately convey the degree of uncertainty in the assessment of respective contaminant groups. Although there is uncertainty for all individual contaminants and in their interactions, the weight of evidence from the assessments of bottom fish deformities in Great Lakes fish indicates that organic contaminants (primarily PAHs, with possible contribution of PCBs) are the primary risk drivers for bottom fish deformities.To respond to the Expert Support comment, we intend to incorporate the results of our review of bottom fish deformities (including benchmarks developed from those studies) and also consider the findings of Gauthier et al. (2014). An assessment of the potential interactions among contaminant groups will be included.*	Satisfactory response.

16 (DFO-2014-015)	Since the toxicity threshold fish tissue residue data did not agree with the presence of deformities, are remediation options also taking into account fish abnormalities? Any future studies should include evaluation of PAH toxicity with respect to fish tissue concentrations.	*Our opinion is that the remediation options should take into consideration what is known about fish abnormalities, including the evidence for likely causes and a range of benchmarks. The uncertainties inherent in the benchmarks derivations should also be taken into account. In our opinion, the most reliable basis for benchmark derivation comes from comparison of sediment concentrations to the presence of elevated deformity rates at other Great Lakes sites. Prior to incorporating this information in the development of the risk refinement deliverable, we would like to discuss with Expert Support an appropriate means of integrating this information with other lines of evidence (e.g., acceptable rate of deformities, how to account for multiple causative agents in SeQO development).* *This issue has also been flagged as Category 3 because the environmental protection goal for deformity incidence has not been clearly defined, and as such, broader consultation may be needed to determine the importance/weight that should be assigned to this endpoint (for overall risk characterization and remediation planning). Presence of deformities on bottom fish is less clear cut as an effects measure in an ecological risk assessment relative to survival, growth, reproduction, and developmental effects. There is also some indication by RMC-ESG that the Cataraqui Stakeholder Group has offered an opinion on the importance of this risk pathway relative to protection of human health and wildlife. Finally, even if the endpoint is assigned equal importance to other effects measures, the issue of*	Satisfactory response.

		acceptable magnitude of response (i.e., degree of elevated incidence relative to regional background) remains.	
17-(DFO-2014-016)	While it is recognized that validation and calibration is not possible for all aspects, whenever possible any models used should validated with ground truthing.	*We agree with the comment, which applies to the RMC-ESG deliverable, and presumably relates to the bioaccumulation models used to link sediment concentrations to tissue concentrations (and dietary intake). That said, it is very challenging to formally validate many of the models applied, particularly for contaminant intake to wildlife. There are some aspects of the modelling that rely mainly on measured concentrations in field media (macrophytes, invertebrates, fish) whereas others rely on modelled concentrations using extrapolation from sediment and/or water concentrations. To address the reviewer comment, we believe that the best approach is to discuss, in the uncertainty analysis, the degree to which the model predictions are supported by other lines of evidence. For example, where PCB concentrations are available in fish tissues, it is useful to compare the measured concentrations with those that would be predicted from trophic transfer modelling based on sediment concentrations.*	Satisfactory response.

18 (DFO-2014-017)	The report states "It is likely that elevated contaminant concentrations in KIH sediments are responsible for the observed brown bullhead abnormalities, although the cause of the DELTs cannot be determined conclusively", however then the next sentence states that "SeQOs for the KIH were not based on deformities in brown bullhead and therefore the definitive cause for observed deformities does not need to be known" (page II-11, paragraph 2). The second statement is incorrect as the fish deformities maybe the resultant of impacts from contamination that is on federal property or originated from federal activity in KIH. This comment requires revision as it pertains directly to fish health in KIH.	*We generally agree with the Expert Support comment. Although conclusive determination of the cause may not be possible, even with additional study, the development of a risk management strategy does not require determinations to be 100% conclusive. The RMC-ESG assignment of deformities to "elevated contaminant concentrations" is not sufficiently specific to be of value for risk management. If contaminant distributions were highly similar among the main contaminant groups (i.e., PAHs, PCBs, mercury, inorganics), the requirement to determine causation would be lower, as management for one substance would simultaneously address others. However, in the KIH, there are substantial areas for which the contaminant "fingerprint" is dissimilar to the areas prioritized by RMC-ESG in Chapter V; for example, areas in the southwest corner of KIH contain PAHs but lower concentrations of inorganics. Rather than exclude fish deformities in the SeQO evaluation, we believe that the existing information on causation and sediment benchmark concentrations be incorporated in the weight of evidence for ecological health. Although there are residual uncertainties with this approach, it is preferable to the assumption that management of other risk pathways will coincidentally manage risks to fish. The degree to which we can use existing information on fish deformities versus additional site-specific studies is an item for discussion with Expert Support. This item has also been flagged as Category 3 because the approach taken depends on the degree of certainty required of the causation*	Satisfactory response.

		assessment. We agree with RMC-ESG that additional studies (e.g., virology, histopathology, etc.) have limitations for the identification of specific causative agents, so even a commitment to further study would not necessarily provide the desired precision in risk estimates or causation assessment.	
19 (DFO-2014-018)	Before proceeding with any plans for remediation work, the study would greatly benefit from sediment stability assessment to evaluate and better understand critical shear stress for erosion of various areas of contaminated sediments, as well as modeling and prediction of the expected shear stress from wind and water flow driven currents and vessels.	*We generally agree with the Expert Support comment. We have had some discussions with the site custodians on this topic, particularly as they relate to the long-term effectiveness of localized dredging where recontamination could occur. At this stage, we believe that it is appropriate to conduct the risk refinement to identify management areas that are a priority for risk reduction. Once complete, the information would assist in determining the types and locations of sediment stability studies. We agree that development of any detailed remediation plans would require consideration of sediment stability.*	Satisfactory response. However, please note above (DFO-2014-004), and as discussed with Jennifer Hughes (Transport Canada) via email February 25, 2015 that DFO is available to assist financially with a study examining sediment stability assessment. Jennifer noted that 'The current workplan does call for a sediment stability assessment to follow, and this will be confirmed once the RA refinement work is concluded. All work for 2015/16, however, would be subject to budget delegation/approval which has not yet been received by TC.'
20 (DFO-2014-019)	The Golder technical memo mentions “there are other risk pathways for which consideration of Anglin Bay remains important”. It would helpful to list the specific pathways.	*In the risk refinement, we will clarify the risk pathways that are drivers for each management unit. The comment made for Anglin Bay was made primarily in reference to surface PAH contamination, which influences the assessments of benthic invertebrates, fish deformities, and possibly human health.*	Satisfactory response.

21 (DFO-2014-020)	Golder states "… some aspects of the ecological risk assessment (especially for wildlife) still rely on screening level approaches for effects"… and "… it limits the degree to which the results can be reliably used for making remedial decisions given the associated uncertainty and conservatism." Does this mean that these aspects require more detailed assessment or would an acknowledgement of the associated risks be sufficient during decision making?	*Golder has provided alternative TRV derivations for chromium and PCBs, and these TRVs have been incorporated to some degree in Chapter IV. What is lacking in the RMC-ESG reporting is the meaningful consideration of these respective TRVs in Chapter V, where they are discounted entirely, giving preference to the Eco-SSLs from USEPA for calculation of SeQOs (in spite of the latter specifically cautioning that Eco-SSLs "are not designed to be used as cleanup levels." We disagree with the rationale provided on page IV-5 of Chapter V to discount this information, and believe that acknowledgement of the risks and uncertainties associated with candidate TRVs would greatly improve the wildlife risk assessment.*	Satisfactory response.
22 (DFO-2014-021)	Golder reports that some statements "…lack balance in terms of recognizing the degree of certainty that was actually achieved." Could the statements be changed to reflect those parts of the risk assessment results that could be referred to with great confidence in order to provide a more truthful recommendation or should the areas of uncertainty receive more attention	*This can be handled directly in the risk refinement, where the level of certainty in each component will be considered in the weight of evidence evaluation.*	Satisfactory response.
23 (DFO-2014-022)	Golder states "the ability to effectively implement a long-term remediation program based on dredging alone…" is affected by the continuous sediment mixing and resuspension. Are there any other recommendations for other remediation methods to include in addition to dredging?	*See response DFO-2014-018 above. There are implications of sediment mixing and resuspension on multiple remediation methods, including those other than dredging. For example, depending on the location, the effectiveness of monitored natural recovery and dredging with clean backfilling would both be influenced by the lateral movement of sediment in the KIH. Effectiveness of remediation in some areas may also be influenced by bioturbation and mechnaical disturbances that*	Satisfactory response.

		influence the vertical distribution of contaminants. As indicated above, we believe that a better understanding of the risk drivers (locations and contaminants) from the risk refinement will help to focus future studies of sediment stability; this approach is consistent with the COA Framework.	
24 (DFO-2014-023)	Golder reports that there is "…concern that the results of the sediment quality triad assessment are summarized in a very broad manner, rather than made location- or unit-specific." In terms of using the information for making site management decisions, would it be more helpful to have results include reference to specific locations or be revised to report on each unit?	*See response DFO-2014-001 above. We believe that summarizing risk outcomes at the scale of management units is the most useful approach. For most receptors, the information at individual stations is too detailed to develop a management framework, whereas grouping all stations is too broad. By identifying areas with similar patterns of exposure and risk, we can identify priorities for risk management at a scale that is practical and meaningful. Where necessary, risks to mobile receptors (e.g., fish and wildlife) can be aggregated through consideration of results from multiple management units.*	Satisfactory response.
25 (DFO-2014-024)	Golder States "the ES comments on the observation of fish deformities in the APEC, and notes that fish tissue COPC concentrations fall below published fish toxicity thresholds. The explanation provided is that the potential interactions among the measured concentrations of COPCs may explain this discrepancy. This is a possibility, although it is speculative." Other studies have shown that COPCs can interact in aquatic environments resulting in synergistic ecological effects. The RMC report would benefit by further elaborating and including further literature references regarding	*Response DFO-2014-024 – See response DFO-2014-014 above. We will incorporate information on possible causes of fish deformities in the risk refinement, including evidence for combined COPC responses (including PAHs) and reference to Gauthier et al. (2014). However, we do not believe that including PAH toxicity in the fish tissue toxicity screening will be useful given that these substances are metabolized in fish. The assessment of PAH toxicity can be accomplished, but entails different methods from whole body PAH chemistry, such as analyses of stomach contents for PAHs, measurement of PAH metabolites in bile, biochemical indicators (e.g., CYP1A activity), examination for DNA adducts in*	Satisfactory response.

	their concerns of increased toxicity to fish from combined COPCs in KIH, particularly PAHs and other COPCs. Please see Gauthier et al. (2014) for recent references. RMC should also consider including PAH toxicity in the fish tissue toxicity screening.	*liver, histological evaluation, somatic indices, etc.*	
26 (DFO-2014-025)	DFO ES highly agrees with the Golder statement that "The elimination of invertebrates and fish at this stage, presumably on the basis of previous stakeholder input, is not justifiable in our opinion. Risks for all receptors should be carried through the Options Analysis prior to making presumptive decisions from stakeholder feedback."	*Agree with comment. One of the challenges with Chapter V is that the SeQOs were developed from consideration of only a subset of the risk pathways. The risk refinement will address this issue by reintroducing risk characterization results for invertebrates and fish and will identify areas where risks to multiple receptors and/or contaminants are overlapping*	Satisfactory response.
27 (DFO-2014-026)	DFO ES highly agrees with the Golder Statement "studies have confirmed that historical deposition of coal tar may be a significant source of PAH contamination within Anglin Bay sediments. The site custodians have an obligation under the COA Framework to continue to investigate these issues as appropriate."	*Agree with comment. That said, we believe that there is now adequate coverage of sampling to develop the risk refinement at the scale of management areas. As the project proceeds toward a management plan, some refinement of contaminant distributions (particularly where contaminants have been observed at high concentrations at depth) may be needed. Our risk refinement will emphasize risks at the surface and near-surface (as these influence current risk levels) with the understanding the deeper contamination will need to be considered as part of the remedial options assessment.*	Satisfactory response.
28 (DFO-2014-027)	Golder states that the "application/effectiveness of remedial options..." is constrained by a lack of understanding of the sediment transport and dispersion pattern. Please include a summary of needs and or a discussion of future plans to address this gap.	*See response DFO-2014-022 and DFO-2014-018 above. Although we agree that better understanding of sediment transport and dispersion patterns will ultimately be required, the risk refinement based on current surface conditions can proceed in the interim and will help frame needs for sediment stability*	Satisfactory response.

		studies.	
29 (DFO-2014-028)	As noted by Golder, the sediment chemistry maps in the RMC report do not include data collected by PWGSC on behalf of Transport Canada and Parks Canada (Golder, page 6). The PWGSC data should be included in the RMC maps.	*See response DFO-2014-005 above. Golder has combined the data from RMC-ESG investigations and data collected by PWGSC on behalf of Transport Canada and Parks Canada. These sources will be included in the risk refinement including associated sediment chemistry maps.*	Satisfactory response.
30 (DFO-2014-029)	Golder states that there are areas of the RMC risk assessment falling short of a DQRA. It would be helpful if these areas were individually identified.	*In the risk refinement, we will discuss the uncertainties for each of the major risk pathways, particularly where such affect the degree of conservatism.*	Satisfactory response.
31 (DFO-2014-030)	Golder states that “there are many aspects of the risk assessment that remain uncertain.” If possible, a description of these aspects would provide clarity.	*The purpose of the risk refinement deliverable is to provide such clarity. Some of the parameters (and risk calculations) will change based on Expert Support feedback. In other cases, the risk calculations may not change but additional discussion of uncertainty may be appropriate.*	Satisfactory response.

32 (DFO-2014-031)	Overall, DFO ES agrees with Golders concerns regarding some of the methods used by RMC-ESG in the risk assessment, and the resultant conclusions and proposed management decisions. Differences between the RMC study and Golder's studies reoccur within the memo, including several instances where Golder indicates RMC understated the linkages between PAH toxicity in benthic invertebrates and fish, and that the RMC report focus on the Parks Canada portion of the site, rather than a complete assessment of both federal properties in KIH. DFO ES also agrees there still appears to be a lot of uncertainty with estimated levels of ecological risk and further work is needed to characterize and manage contamination in Kingston Inner Harbour to better estimate ecological risks. Overall, the report contains valuable data and information. Ongoing work in KIH would greatly benefit from a collaborative approach between Parks Canada and Transport Canada to better address data gaps, avoid repetition of effort, and obtain a more comprehensive understanding of the overall contamination characteristics and associated remedial options for both federal properties in KIH.	*We are pleased that Parks Canada and Transport Canada have collaborated in the ongoing risk refinement. A key goal of the deliverable will be to reconcile the valuable data and information from multiple studies, some of which were conducted in parallel. It would have been difficult for RMC-ESG to incorporate all the available data when investigations were ongoing.*	Satisfactory response.

Disclaimer:

Fisheries and Oceans Canada provides these comments as per our role as Expert Support for the Federal Contaminated Sites Action Plan (FCSAP). This advice is not intended to replace your own independent scientific, technical and legal advice as to how to establish your own contaminated site risk management plan, how to remediate your contaminated site, or comply with federal or provincial environmental law. Fisheries and Oceans Canada assumes no responsibility or liability regarding any decisions you make as to how you comply with that law.

References:

Baumann, P.C. 2010. Data Analysis and Fish Tumor BUI Assessment for the Lower Great Lakes and Interconnecting Waterways. Prepared for Environment Canada.

Baumann, P.C. 2013. Liver Tumor Prevalence in St. Marys River White Sucker: A Discussion of Probable Causes. Prepared for Environment Canada. March 31, 2013; revised July 28, 2013

Benoit, N. and D. Burniston. 2010. Cataraqui River Project Trackdown: Follow-up study on success of remediation efforts in the Cataraqui River 2006. Prepared for the Eastern Region of the Ontario Ministry of the Environment, April 2010

Golder Associates Ltd. 2013(draft). Draft Federal Contaminated Sites Action Plan (FCSAP), Ecological Risk Assessment Guidance Module 5: Defining Background Conditions and Using Background Concentrations. Prepared for Environment Canada. April 2013

Great Lakes Commission. 2002. An overview of U.S. Great Lakes Areas of Concern. Prepared by the Great Lakes Commission under a cooperative agreement with the U.S. Environmental Protection Agency Great Lakes National Program Office.

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

Golder 2014 – review comments

August 1st, 2014

Jennifer Hughes
Senior Environmental Officer
Transport Canada – Ontario Region
4900 Yonge Street
North York, Ontario M2N 6A5

Dear Jennifer,

Subject: Peer Review Comments for:
Transport Canada Waterlot Sediment Investigation – 2013.
Kingston Inner Harbour, Kingston, Ontario (March 27, 2014)

Environment Canada has received and reviewed the reports titled "*Transport Canada Waterlot Sediment Investigation – 2013. Kingston Inner Harbour, Kingston, Ontario (March 27, 2014)*" pprepared by Golder Associates Ltd. The review was completed as per our role as an expert support department under the Federal Contaminated Sites Action Plan (FCSAP). Please see our attached comments.

Please contact Maria Petrou if you have any questions with respect to these comments.

Maria Petrou (416)739-4843, Maria.Petrou@ec.gc.ca

cc : Angela Li-Muller, Health Canada
Tara Bortoluzzi, Department of Fisheries and Oceans
Jody Willis, Department of Fisheries and Oceans
Anita Wong, Environment Canada
Rui Fonseca, Environment Canada
Jesica Moreno-Colacci, Environment Canada

Environment Canada – FCSAP Expert Support Peer Review Comments

Site: Kingston Inner Harbour
Report Title: *Transport Canada Waterlot Sediment Investigation – 2013. Kingston Inner Harbour, Kingston, Ontario"* (March 27, 2014)
Prepared By: Golder Associates Ltd.
Prepared for: Transport Canada
Date Reviewed: August 1st, 2014
Reviewed by: Environment Canada - Maria Petrou, Maria.Petrou@ec.gc.ca, 416-739-4843

One of Environment Canada's expert support roles within the Federal Contaminated Sites Action Plan (FCSAP) is to provide advice and information on contaminated sites management to the custodians of Federal contaminated sites. The following comments are provided in response to the report listed above and are for your consideration.

General Comments

Environment Canada has not reviewed previous Transport Canada studies by Golder referenced in this report and cannot comment on the conclusions drawn from them. Also, as this particular sediment study has been conducted in order to fill gaps from such previous studies in the Kingston Inner Harbour by Golder, Environment Canada cannot comment on whether the identified gaps or areas identified for remediation (FF0, MF1 and MF2) are appropriate, or other such conclusions drawn from previous studies. The context of this study is limited and is not incorporated as part of this review. The focus of this review is on the specific results and interpretation from this sediment study alone.

It is imperative that data used to characterize contamination in the harbour be representative of current conditions. Data collected prior to dredging or remediation activities should not be used without confirmation that it is representative of current conditions. Please note that dredging took place in 2004-2005 near the Emma Martin Park to address PCB contamination (Benoit and Burniston, 2010). Other activities may have also occurred.

There is concern of the level of protection of aquatic life drawn in the conclusions. Benchmarks for PAHs and PCBs used as 'low' and 'moderate' risk are set too high and need to be revisited. Methodologies used for organic carbon normalization do not clearly demonstrate how their level of protection is equal to or less than the level of protection that is inherent in the CCME guidelines for sediments.

Introduction

The introduction and context of this study is limited. Specific information such as background on what is understood of the harbour prior to this investigation – especially the area under investigation, the basis of conclusions drawn from previous studies, how the data gaps were identified to move forward with this study, and what specific findings are required to fill in these gaps would be beneficial and recommended to include in this study.

Methods

Please include samples taken from FF-1 in the Field Sampling and Analysis section (page 3, section 2.2). There are three additional samples (Grab 18, 19, and 20) not accounted for. Also, please provide rationale as to why there were no core samples taken in the FF-1 area.

Sediment Chemistry Results

The report indicates that data used to generate the surface chemistry maps shown in figures 1-8 are compiled from data collected in the years 2003-2013 (page 5, section 3.0). References should be provided to indicate the sources of this data. In addition, screening methods on how this data was selected and validated as appropriate and representative of current conditions should also be included. It is imperative that data used to characterize the contamination in the harbour be representative of current conditions as site management and remediation decisions are based on this information. Data collected prior to dredging or remediation activities should not be used without confirmation that it is still representative of current conditions. Please note that there has been dredging activities in 2004-2005 near the Emma Martin Park to address PCB contamination (Benoit and Burniston, 2010). Other activities may have also occurred.

Environment Canada does not agree with the PAH and PCB benchmarks presented for low and moderate risk (page 6, section 3.0) that are incorporated in the figures and used to draw conclusions. These benchmarks are set too high. Environment Canada believes that concentrations of 10 ppm total PAH are a marker above which significantly elevated tumor rates are likely (Baumann 2013). Furthermore, a 5% prevalence rate of liver tumours should be interpreted as an indicator for environmental degradation (the Great Lakes Commission 2002) and prevalence of liver neoplasms in urban areas without any major point sources are expected to have liver neoplasm prevalence of 2% or less (Baumann 2010). In addition, the benchmarks presented in this report use external and liver lesion incidence rates interchangeably, however their occurrences are not one in the same. There are strong correlations found with liver neoplasms and PAH specifically; external lesions are not as strongly correlated and are subject to various confounding factors (such as viruses and injury). The benchmarks, as well as the figures and conclusions drawn using these benchmarks need to be revisited.

The Organic Contaminants section 3.2 on page 8 concludes that surface sediment PCB data collected in 2013 are not expected to be sufficiently high to exhibit toxicity to benthic invertebrates based on suggestions of the SQG derivations. Please provide a clear reference to which SQG derivations and publications are being referred to and how exceedances of CCME Probable Effects Levels can be dismissed based on these findings. Furthermore, as noted in the comments above regarding benchmarks, the "moderate risk' benchmark for PCBs set for 1.0 mg/kg needs to be revisited and should not be used to draw conclusions that toxic effects suggest '*a modest potential for increased tumor prevalence in fish*'.

Similarly, moderate risk benchmarks for PAHs, as referred to on Page 8, section 3.2 need to be revisited.

The results presented in Table 1 show CCME PEL and PSQG-Ontario SEL exceedances of lead throughout all areas under investigation (FF0, FF-1, MF1, and MF2) and of mercury throughout most of the areas under investigation (FF0, MF1, and MF2) however there is no mention of this in the summary of results. These are fairly pronounced and consistent exceedances. Please explain the significance of these findings and the implications they have on future decisions and site management requirements.

Copper exceedances were prevalent in FF0 as shown in Table 1. These exceedances were explained in the results as possibly caused by current and historic use of antifouling paints used on boat hulls. As this is a possible on-going source, should the extent of ongoing contamination and impacts to the harbour be further investigated and addressed – if required – prior to any remediation activity?

Detection limits for several parameters (mainly PAHs and PCBs) are greater than the guidelines. The report should identify where these occur, how results below detection limits are interpreted, and how they affect the conclusions of the study.

Figure10 "*Proportions of Individual PAH Components Relative to the Total of 2-, 3-, 4- and 5-ringed PAH groups and to the Site Total PAH Concentration for Anglin Bay Areas Sites*" as mentioned in the list of figures and on page 12, section 4.2, is missing from the report.

Organic Carbon Normalization & Bioavailability Assessment

Environment Canada (1998) has been referenced on page 5, section 2.3.1.2 however it is not listed in the reference section. Please include this reference and how it pertains to Environment Canada's most current stance on PAH bioavailability.

Subsequent to the Treasury Board Policy of Management of real Property (section 6.1.12), FCSAP considers acceptable risk to be any risk that is equal to or less than the level of protection that is inherent in the CCME guidelines. For sediments in particular, this is to protect all forms of aquatic life and all aspects of the aquatic life cycle. Generally speaking, sediment concentrations must be below which adverse effects rarely occur. It is unclear how the use of organic carbon normalization provides an equivalent level of protection to CCME guidelines. If this approach is to be adopted, specific reference to the methodology used must be provided as well as a clear explanation and rationale as to how the level of protection is maintained by using guidelines and methodologies of another jurisdiction when CCME guidelines are already available.

Source Investigation

The results summarized for the storm sewer runoff investigation provide a general overview of the study's findings however more detail would be beneficial and recommended. For example, figure 2 provides a map of the entire harbour; a more appropriate representation would be of a map specific to the area under investigation as well as the location of the storm sewer discharge and the location of historical sources. As shown, it is not clear how the conclusions are validated.

Conclusions

Environment Canada cannot provide specific comments to the conclusions provided in this study, as analysis methods and benchmarks used within the current study need to first be addressed.

Please specify what contamination is referred to in the following sentence (page 13, section 5.0): "*Results of this investigation also further confirm the conclusions of the source evaluation (Golder 2013a) that historical (legacy) sources, rather than ongoing sources, are primarily responsible for the observed pattern of sediment contamination in the Transport Canada water lots of KIH*".

Next Steps

Environment Canada cannot comment on the specifics on the 'next steps' required as previous reports and findings have not been reviewed.

Moving forward, an appropriate step would be for Transport Canada can to work collaboratively with the other federal custodians of the Kingston Inner Harbour (Parks Canada, and Department of National Defence) to address data gaps and achieve a comprehensive understanding of the harbour for all federal properties as well as avoid duplication of effort.

Environment Canada provides these comments as per our role as Expert Support for the Federal Contaminated Sites Action Plan (FCSAP). This advice is not intended to replace your own independent scientific, technical and legal advice as to how to establish your own contaminated site risk management plan, how to remediate your contaminated site, or comply with federal or provincial environmental law. Environment Canada assumes no responsibility or liability regarding any decisions you make as to how you comply with that law.

References

Baumann PC. 2010. *Data Analysis and Fish Tumor BUI Assessment for the Lower Great Lakes and Interconnecting Waterways*. Prepared by Paul C. Baumann submitted to Environment Canada.

Baumann PC. 2013. *Liver Tumor Prevalence in St. Marys River White Sucker: A Discussion of Probable Causes. Prepared by Dr. Paul C. Baumann, under contract to Environment Canada.* March 31, 2013; revised July 28, 2013

Benoit, N. and D. Burniston 2010. *Cataraqui River Project Trackdown: Follow-up study on success of remediation efforts in the Cataraqui River 2006*. Prepared for the Eastern Region of the Ontario Ministry of the Environment, April 2010

Great Lakes Commission. 2002. *An overview of U.S. Great Lakes Areas of Concern*. Prepared by the Great Lakes Commission under a cooperative agreement with the U.S. Environmental Protection Agency Great Lakes National Program Office.

RMC – 2014 (follow-up comments)

Comment Number	Environment Canada''s original comment	Golder Associates Comment Number	Comment from Golder Associates Technical Memorandum	Page on Technical Memoradum	EC's comment to Golder's Technical Memdorum (Adriana Glos)
1	n/a	n/a	Divison of comments: *Category 4 – Topic raised is beyond the scope of the risk refinement (i.e., feedback is relevant but relates to future stages of site management), or relates to RMC-ESG deliverable details not within Golder's scope or control.*	p.2/51	Enviornment Canada requests further clarification regarding category 4 as it pertains to the division of comments given by Golder Associates. Further clarifications on what consititutes a comment or topic being beyond the scope of the risk refinement or beyond Golder's scope or control should be explained.
2	The Area of Potential Environmental Concern (APEC) is not clearly defined. A site map identifying the site's boundaries is not included in this report. It is unclear whether the APEC referred to in this report encompasses all/part of the Orchard Street Marsh, the Parks Canada and Transport Canada waterlots entirely, or portions of each. Given that risks are assessed and remediation measures are recommended in this report, a clear picture of the area under investigation is critical .	EC-2014-001	*See response DFO-2014-001 above. The site boundaries and subunits (management zones) within the site will be clearly presented in the risk refinement deliverable. We will also strive for clear and consistent terminology in the discussion of geographical areas.*	p.18/51	APEC is defined as a portion of a site where contamination is suspected or confirmed. As an APEC can include many COPCs, it is important to ensure that all possible COPCs are included. Proper testing and identification of COPC's within an APEC can then be delineated. Environment Canada requests the custodian provide a clearly defined APEC map.
3	The "Cataraqui River Project Trackdown" study as referenced throughout the report (Benoit and Burniston, 2010) involves a follow-up study on dredging activities in 2004-2005 near the Emma Martin Park to address PCB contamination. The outcome of the study and/or changes of the harbour from this activity, as well as any other remediation activities that have occurred at the site should be addressed in this report.	EC-2014-002	*See response DFO-2014-005 above. The surface sediment data will be screened to exclude non-representative data.*	p.18/51	Golder's response seems reasonable to Environment Canada. However, when the datapoints are reviewed it is important to provide detailed explanation as to why certain data sets were considered outside the footprint of the western shoreline remediation in 2004-2005. In addition, Environment Canda requests further clarification as to what constitutes non-representative data.
4	The Cataraqui River Stakeholder Group (CRSG) is described on page iii and lists Environment Canada as a member and key stakeholder. We would like to clarify that the Environment Canada FCSAP Expert Support team is not a key stakeholder nor is it a member of the CRSG. Our involvement is to support and provide technical advice to federal custodians under the FCSAP framework; in this case Parks Canada and Transport Canada.	EC-2014-003	*This comment, and several similar comments raised by Expert Support, relate to the comments made in the RMC-ESG deliverable concerning the degree of acceptance or endorsement of risk assessment approaches and conclusions. We understand that there are some technical areas for which there has not been consensus or endorsement by the Expert Support departments. Our approach will be to incorporate the technical input of the Expert Support depatments, also acknowledging previous comments from these departments based on earlier draft versions of the RMC-ESG reporting package. It is not our intention to engage the Cataraqui River Stakeholder Group until these technical refinements are complete.*	p.18/51	Environment Canada notes that Golder's response is a category 4 comment. Environment Canada would like to draw Golder Associates attention to our previous comments where we state that EC expert support under FCSAP is not a member of the Cataraqui River Stakeholder Group (CRSG).
5	Page iv states that "the five chapters in this report summarize everything that is known about the Harbour". This is a misleading and inaccurate statement as there are other studies and additional knowledge of the harbour that is not included in this report. This statement should be revised	EC-2014-004	*See response DFO-2014-003, above. We agree with the comment, but will address the underlying issue in the risk refinement deliverable, rather than attempt to modify the RMC-ESG documents .*	p.19/51	Environment Canada notes that Golder's response is a category 4 comment. Although there is additonal information and Golder has accepted EC's original comment, EC would like to re-iterate that the rationale behind the comment was to showcase that the summary previously provided did not include all known information.
6	The Next Steps outlined on page xii indicate that stakeholders have identified project aims to guide the assessment and sediment decision-making process. It is important to note that the harbour is on federal land and must also follow the federal framework for contaminated sites.	EC-2014-005	*We agree with the comment. Several parts of the RMC-ESG reporting package indicate that the Cataraqui River Stakeholder Group (CRSG) considered as a decision-making body (i.e., decider of risk pathways and relative importance of various receptor groups). We consider the CRSG engagement as an important consultative process but also one that cannot be used to deviate from the federal framework for contaminated sites. We intend to follow the COA Sediment Assessment Framework as the primary process for evaluating risks under FCSAP; this means that risk pathways to benthic invertebrates and fish, for example, must be carried through the risk characterization phase .*	p.19/51	Environment Canada would like to note that the Cataraqui River Stakeolder Group (CRSG) provides guidance to assist sediment contamination and develop management strategy.

7	Sediment data between 1991 and 2008 have been used to generate sediment maps of the contaminated area in the Kingston Inner Harbour as indicated on page II-2 and Table II-1. Given that sediments in this shallow harbour are subject to movement, resuspension, and disturbance, and ongoing sources of contamination have since been mitigated, data from the 1990's (over 20 years old) may be out-dated and should be assessed. Availability and use of more recent data from newer studies should also be explored.	EC-2014-007	*See response DFO-2014-005 above. The comment is nearly identical to comments raised by DFO.*	p.19/51	Environment Canada recommends detailed explanations when data information older than 5 years is included within the risk assessment.
8	As indicated above, the Area of Potential Environmental Concern (APEC) is not clearly defined. A site map identifying the site's boundaries is not included in this report. It is unclear whether the APEC referred to in this report encompasses all/part of the Orchard Street Marsh, the Parks Canada and Transport Canada waterlots entirely, or portions of each. Given that risks are assessed and remediation measures are recommended in this report, a clear picture of the area under investigation is critical.	EC-2014-008	*See responses EC-2014-001 and DFO-2014-001 above.*	p.20/51	Please see Environment Canada's previous comment #2.
9	There were no species at risk evaluated for risk. It should be verified that no species at risk inhabit or frequent the site.	EC-2014-014	*As noted elsewhere in the FCSAP comments, there are listed species at the Site. We will evaluate whether risks to these species are likely to be greater, equal to, or less than those identified for the receptors of concern formally evaluated by RMC-ESG. Because risks to wildlife were evaluated at the level of individual organism, rather than population or community level, it is possible to make such comparisons.*	p.21/51	Environment Canada would like to clarify that the species at risk noted in our original comment pertained to species listed or covered by the *Species at Risk Act*.
10	n/a	n/a	n/a	n/a	

Golder 2013a – dialogue

March 20, 2014

MEMO: EC comments to Golder responses to Expert Support review of the Kingston Inner Harbour "*Sediment and Gap analysis and Fish Literature Assessment*" including Appendix A – "*Parks Canada Water Lot Sediment Quality Update*" and Appendix B - "*Literature Assessment of Fish Lesions in Bottom Fish*".

Thank you for the opportunity to review and discuss responses provided by Golder on Environment Canada's review of the Kingston Inner Harbour sediment and gap analysis and fish literature assessment on February 24, 2014. The discussion had focussed on Category 2 Environment Canada responses only. As there were many discussion points during the follow-up call we have provided a summary of key points raised at the call embedded in blue text to Golder's responses for your consideration.

Please do not hesitate to contact Maria Petrou or Debbie Audet if you have any questions with respect to the information provided.

Maria Petrou (416) 739-4843
Debbie Audet (416) 739-4215

Teleconference Call:

Date & Time:

Tuesday March 18, 2014 @ 11:30 – 1:00 EDT

Attendees:

PWGSC – Javier Banuelos
PC – Mylène Salvas, Harry Szeto, Mikailou Sy
Golder – Gary Lawrence, Shawn Seguin, Mike Graggen
EC – Maria Petrou, Debbie Audet

Golder provided background during the introduction of the teleconference call.
It was underscored that this study is one piece of a larger set of studies and that overall there is a lot of characterization at the Parks Canada water lot. This particular study under review was not meant to provide a full characterization but fill in identified gaps in sediment toxicity and fish deformities.

1.0 RESPONSE TO ENVIRONMENT CANADA COMMENTS

1.1 Overview Report

EC-1: *Section 4.1.1 Bioavailability of Metals. Environment Canada cannot comment on the statement "confirmation of the lack of metal-based toxicity to aquatic invertebrates comes from the TIE results of Golder (2012b) which tested KIH sediments with elevated metals concentrations relative to sediment quality guidelines and reference conditions". This report is not reported to have been reviewed by Environment Canada.*

EC-1 Response (Category 2): We understand the difficulty in providing comments on conclusions reached in other technical documents. The Golder (2012b) study was conducted using sediments from the southwest corner of KIH, near Anglin Bay and Douglas Fluhrer Park. Those studies indicated that PAHs were the most likely cause of observed responses in sediments, with no indication of toxicity due to metals. Caveats to those results include the fact that the TIE was conducted over a limited range of some metals (e.g., chromium concentrations in these samples were not as high as those observed in some Parks Canada samples) and the potential for differences in bioavailability across differ portions of the KIH.

Additional information was provided during the call by Golder and was appreciated. It was mentioned that the TIE study consisted of two samples taken at Anglin Bay; one of which was inconclusive and the other indicating that PAHs were the most likely cause of toxic effects. It was also noted that the location of these samples are in a different location than the area of focus in this study and so there is a level of uncertainty. The biggest finding in this study was that there was a lack of toxicity due to metals.

The comment by Environment Canada above (EC-1) is still maintained as we have not reviewed this study.

EC-2: *Section 4.1.2 Uncertainty in Fish Tissue Concentrations. In the report, the CLAW team provides results from Ministry of Environment and ESG from 1999-2009. Some clarification is needed to explain the results (i.e. what is meant by "33 measurements of arsenic", etc.). Furthermore the referenced document (ESG 2010b) is found within the list of references.*

EC-2 Response (Category 1): We agree. The missing ESG (2010b) reference refers to the data summary for tissue data compiled by the Environmental Sciences Group (ESG) at the Royal Military College (RMC). This document may be in the process of revision, as indicated in comment HC-14

EC-3: *Section 4.1.3 Cause of Sediment Toxicity Unknown. Environment Canada disagrees with the statement "despite sampling that targeted worst-case locations… and/or maximum concentrations of* *substances of concern, strong toxicity responses were not observed" and does not agree that this issue is now addressed. Please see review comments for Appendix A for reasoning.*

EC-3 Response (Category 2): We will respond to this comment in the Appendix A discussion.

Please see Appendix A responses and comments.

EC-4: *Section 4.1.6 Cause of Bottom Fish Abnormalities Unknown. Environment Canada does not agree that the benchmarks formulated from the Fish Literature Review (Appendix B) should be combined with other lines of evidence for guiding management of sediments before they are reviewed and modified. Please see review comments for Appendix B for reasoning.*

EC-4 Response (Category 2): We will respond to this comment in the Appendix B discussion.

Please see Appendix B responses and comments.

EC-5: *Section 4.1.11 Remote Non-Point Sources. The report mentions that many rounds of sediment quality assessments have consistently indicated low concentrations of contaminants of concern in the reference areas upsteam of Belle Island, and low ecological risks. In reviewing Figures 2-4 in Appendix A, contamination appears to also occur on the northern portion of the harbour. Figure 2 shows PAH concentrations of 4-15 mg/kg found on the north-western corner, and north of Belle Park. Figure 3 shows PCB concentrations of 0.3-1 mg/kg on the northern tip of Belle Island. Figure 4 shows high chromium concentrations extending beyond Belle Island, and to the north of Belle Island. There is also a pocket of high contamination along the western shore north of Belle Island. Other contaminants such as lead, zinc, and mercury have shown to be present in maps within the RMC-ESG Chapter 2 report. Has it been confirmed that there are no ongoing sources of contamination in this northern portion of the harbour and have these areas of contamination been assessed in order to confirm that there are no risks?*

EC-5 Response (Category 2): This issue would best be discussed in a conference call. The few sampling points that have exhibited elevated concentrations of substances appear to be limited in spatial extent, and not connected to point sources. The concentrations of these substances north of Belle Island are generally below levels shown to be of concern based on the results of the sediment quality triad investigations and the biological monitoring conducted by RMC-ESG.

It was noted by Golder that reference stations chosen in previous studies north of Belle Island, took into account possible areas of local contamination. Also, in terms of contaminated areas posing possible risks, Golder noted that small point sources were evident however were confident that these sources weren't significant north of Belle Island. Environment Canada has no further comments.

EC-6: *Section 4.2 Pathway Forward. The report lists ongoing sources including the combined sewer over overflows, the Kingscourt storm water, the former Belle Landfill, the Orchard Street Marsh, and Emma Martin Park. Environment Canada would like to highlight the importance of addressing ongoing sources and ensuring that all possible sources have been identified.*

EC-6 Response (Category 3): Separate assessments of contamination sources (ongoing and historical) have been prepared for the Parks Canada property and the southwestern shoreline of the Transport Canada property. We agree that addressing ongoing sources is an important aspect of a sound management plan for KIH.

EC-7: *Environment Canada agrees that a harmonized approach between Transport Canada and Parks Canada would be the most effective path forward.*

EC-7 Response (Category 3): We agree, although such broad scale management is beyond the scope of this specific deliverable.

EC-8: *Environment Canada cannot comment on the revised TRVs. The (Golder 2012b) document is not reported to have been reviewed by Environment Canada.*

EC-8 Response (Category 3): We assume that the document referenced here is Golder (2012a), which presents the revised wildlife TRV assessment for PCBs and chromium.

1.2 Appendix A: "Parks Canada Water Lot Sediment Quality Update"

EC-9: *General Comments on the Sediment Toxicity Study: With regards to the selection of sample locations in the sediment toxicity study, Environment Canada does not agree with the reference station (2012-L) and with results that are compared with station (2012-L) as a reference. This station is inappropriate as a reference as it was collected within the area of study for contamination and toxicity, and despite its relatively lower concentrations, does not account for the possibility of heterogeneity within the sample. The CLAW team states that station (2012-L) "is not a true reference as concentrations of some analytes are greater than reference conditions" in section 3.2, however the report continues to use it as a reference and draw conclusions in comparing results of other stations with station (2012-L). For example, in the discussion in section 4.0, the report states "overall, the C. dilutus testing yielded toxicity responses that were low for all stations except for 2012-H". This result is in comparison to station (2012-L).*

EC-9 Response (Category 2): We would like to discuss this issue via teleconference. Although we recognize the limitations of station 2012-L in terms of being a "true reference", we believe that discounting the station entirely is inappropriate. Although the station was located within the area of study, it is located farthest from the suspect area of greatest contamination (mouth of creek draining Orchard Street Marsh). Most individual PAHs in this sample were non-detect, and all individual PAHs were below ISQGs, with a total PAH concentration of less than 0.71 mg/kg dw. The only metal exceeding ISQGs was chromium 110 mg/kg, a level that is an order of magnitude lower than most stations in the southern KIH, and also within the range of concentrations observed in the northern KIH. The PCB concentration of 0.055 mg/kg is close to the ISQG. Considering that the site is located in an industrialized harbour, it would be difficult to obtain sediments cleaner than those in 2012-L without moving the collection to substantial distance from the study area. Even if such sediment were collected, the matching of physico-chemical attributes of the sediment would be difficult. We consider the relatively clean sediment chemistry in 2012-L to be fortuitous and suggest making best use of this sediment as a benchmark against which more contaminated sediments can be compared. With respect to heterogeneity, it is highly unlikely that sample homogenization ineffectiveness could account for such a large difference in sediment chemistry profile. The RPD values we obtained (Table 2) do not indicate that substantial contamination would be present in a single field duplicate that would not be detected in the second duplicate. Furthermore, the role of a negative control sediment in a laboratory sediment toxicity test is not for making determinations of effect size. A negative control is intended primarily for QA/QC purposes, and the nature of the substrate is often dissimilar to field-collected sediments.

While it was noted by Golder in the discussion that 2012-L was not intended to be a reference location and the study was not initially designed as a comparison study, the results are presented as such and draw conclusions based on comparing results between station 2012-L and other sampling locations. Given that station 2012-L is not a true reference, and that there were no other reference stations for this study, uncertainties in the conclusions drawn from this approach should be appropriately discussed. Final conclusions reached should be also revisited.

A gradient approach is also an acceptable approach however the report was not presented as a gradient study; toxicity results in relation to distance from a contaminated zone or to contaminant concentration were not provided.

It was raised by Golder that this study is a small part of a larger collection of studies and is meant to fill-in a data gap. Clarity is required on how the information gathered from this study fills in any gaps and how it complements older studies.

EC-10: *The species used for the sediment toxicity study was Chironomus dilutus. This is a relatively hardy species. The Canada-Ontario Decision Making Framework states that "typically, laboratory sediment toxicity tests are conducted with three or four appropriately sensitive, standardized sediment-dwelling and/or sediment associated test organisms (e.g. Hexagenia, Hyalella, chironomids, oligochaetes) that are reasonably similar to those found at the site. Since this study was conducted to support and refine the application of this decision making framework, the use of C. dilutus alone is not sufficient in supporting this framework.*

EC-10 Response (Category 2): The additional testing conducted in the Parks Canada waterlot in 2012 was intended to augment previous testing, and was not intended to provide a battery of test endpoints. The comment regarding purported hardiness of *Chironomus dilutus* may be applicable for some sites, but does not appear to apply to this site. In fact, comparisons of the relative sensitivity of *C. dilutus* relative to *H. azteca* indicated that in KIH sediment, the former was most sensitive; hence its selection in this program. Selections of sediment toxicity tests for the KIH have relied on results of a number of bulk sediment toxicity tests, including:

- The PCB Trackdown study (Watson-Leung, 2004), in which the Ontario Ministry of the Environment (MOE) and Environment Canada (EC) conducted biological tests and chemical analyses using sediments from eight field locations on the Cataraqui River. The laboratory organisms included a midge (Chironomus tentans), a mayfly (Hexagenia sp.) and fathead minnow (Pimephales promelas).

- The reference listed above (Watson-Leung, 2004) does not provide supportive evidence that *C. tentans (C. dilutus)* is more sensitive than *H. azteca* in the Cataraqui environment. Variability in mortality for *C. tentans* in this study was observed for the control population using sediments from Lake Erie and Honey Harbour Georgian Bay. Furthermore, these mortality results were suggested to be a cause of "*poor organism health or handling stress*".

- In conjunction with the RMC Triad investigations (Tilley, 2006) Microtox™ toxicity analyses were conducted on 20 sediment samples using the luminescent bacteria *Vibrio fischeri*. Five sediment samples from the Triad design were also tested for toxicity to the freshwater amphipod *Hyalella azteca* using a 14-day exposure with survival and growth endpoints.

From the above studies, the midge growth endpoint was observed to be the most sensitive indicator of sediment toxicity (this is not supported in the above studies; see comment under Watson-Leung 2004). This finding was confirmed in expanded toxicity testing in support of the PQRA and DQRA stages of sediment quality assessment for the Transport Canada water lot.

It was raised by Golder that the *C. dilutus* species has shown to be more sensitive in the Cataraqui environment which is why this species was chosen. As it is extremely unusual for *C. dilutus* to be a relatively sensitive species in the benthic community, strong supportive evidence with sufficient references reaching reliable conclusions that this species is the most sensitive indicator of sediment toxicity should be included in the report along with the rationale.

It was raised by Golder that the scope of this study was meant to only augment previous studies and a battery of species was not necessary. The report did not provide results from previous studies in order to place the results of this study into context and indicate how data gaps had been filled. As presented, this is a stand-alone study.

EC-11: *The results shown in table 3 indicate that station (2012-L) had a survival rate of 68% showing a greater than 30% death rate. Three of the six field stations resulted in the same survival rate. In comparison, the lab control survival rate was 96%. Given the significant death rates of all field samples, the unreliable location of the single reference station, and the relative hardiness of the C. dilutus species, conclusions of a low-response drawn from this study would be highly questionable.*

EC-11 Response (Category 2): On the basis of differences of opinion concerning the hardiness of the test endpoint and the value of reference comparisons, we would like to discuss this further. Furthermore, the reduced performance of Station 2012-L relative to negative control is an important consideration for interpretation of all test results given that the potential for chemical-induced toxicity is so low for this sample. Other sediment characteristics beyond chemistry can have a significant influence on test results, and for this reason, comparison to reference sediments that are well matched in these variables provides important context.

While sediment characteristics beyond chemistry (such as percent sand, silt, clay, organic matter) also play an important role in affecting the growth and mortality of organisms, a comparison of characteristics between 2012-L and the other stations to ensure similarity was not provided. Table 1 in the report indicates that 2012-L had the highest percentage of sand and lowest percentage of clay to all other samples. It was also located within the mouth of the creek between Belle Island and the Belle Island landfill; a relatively high erosional zone.

During the discussion of this comment, and in relation to the EC-3 comment and response, clarity was sought from Golder as to what was considered as a strong toxicity effect as the study concluded that strong effects were "*not observed*". This rationale should be included in the report, as well as the application of these measured endpoints to the Canada-Ontario decision making framework on which was mention this study was following. Please also note that in the Canada-Ontario framework, adverse effects are considered "*likely*" if 50% or more difference relative to reference is found in one or more toxicological endpoints, and "*may or may not occur*" if 20% or more difference relative to reference is found (section 2.2.7, Step 5, Table 1). Please also note that any results that fall within *or* above the 20-50% range are treated similarly (section 2.2.7, Step 5, Table 2) where further investigative work (such as TIE) is recommended in the decision matrix. Given that a large number of measured endpoints of this study fall well within the 20% to 50% (ex: all growth endpoints in comparison to 2012-L are between 34-48% different), implications of the results and path forward with respect to the Canada-Ontario framework should be appropriately discussed.

EC-12: *Section 2.3 Field Sampling and Analysis. Sampling methodology should be described in the report. Field sampling logs indicate that samples were collected using various methods; ponar grab samples consisting of three composites, and spoon samples of unknown composites. As different sampling methods can create biases, an explanation as to why these different methods were used and how/if the collection maintained consistency and comparability between methods (e.g. collected at similar depths respective to surface sediments, etc.) should be included.*

EC-12 Response (Category 2): Agree with need for additional documentation. However, as samples were homogenized prior to placement in jars, and included similar sampling depths, the potential for minor differences to significantly affect toxicity is low.

This was not discussed during the teleconference call however please note that different methods in field sampling methodology introduce different bias. Collection should be the same for all samples in order to even these biases between all samples. This is especially important with sediment chemical analysis upon which the level of contamination is based.

EC-13: *In section 2.3.1 - Sediment Chemistry Analysis – the relative percent difference (RPD) of 40% seems high. Also, the last paragraph describing the use of method detection limits (MDL) is difficult to follow and requires clarification.*

EC-13 Response (Category 2): The RPD of 40% for duplicate analyses is not atypically high. For comparison, quality control procedures for metal analyses from USEPA (2002) recommend a relative percent difference (RPD) of <35%. Acceptable RPDs for organic substances vary by jurisdiction but are generally higher than for metals. We can provide increased clarity on the relationship between RPD values and MDLs.

No further comments. We agree with rational that has been presented.

EC-14: *In section 2.4.2 - Sediment Toxicity - the reference station (2012-L) is inappropriate; it was collected within the area of study for contamination and toxicity and should not be used as a reference.*

EC-14 Response (Category 2): For reasons specified above, we believe that the reference station is appropriate for consideration.

EC-15: *Section 3.1 Sediment Chemistry. While Figures 2-5 provide an updated spatial depiction of contaminants within the Kingston Inner Harbour, several metals with exceedances were not included such as arsenic, lead, zinc and mercury. As these metals were part of the sediment chemistry analysis, it would be beneficial that the updated spatial figures include these metals as well.*

EC-15 Response (Category 2): These substances were included in PQRA and DQRA reports, but were not included in this document as these substances are not risk drivers for the remedial options currently under consideration. Spatial profiling of these substances was beyond the scope of our contract with PWGSC.

EC-16: *In section 3.1.2 – Organic Contaminants – in the final bullet, station 2012-A cannot be found on the reference map (Figure 1). Is this intended to be Station 2012-E?*

EC-16 Response (Category 1): Agreed. Station 2012-A was cut off in Figure 1 because the inset box did not extend far enough south. From the other figures you can see that 2012-A is found slightly farther south in the Transport Canada water lot.

EC-17: *(Appendix D) Nautilus Environmental – Sediment Toxicity Report. This report was not included in the document*.

EC-17 Response (Category 1): It has been include in the updated (April 1, 2013) version.

1.3 Appendix B: "Literature Assessment of Fish Lesions in Bottom Fish"

Clarification was asked in regards to the data used to plot the concentration-response figures. Environment Canada wanted to know if only freshwater fish species were included in the plots or if it also included data from marine environments. Golder was unsure if Figures 4-7 plotted freshwater data only, or also included data from marine and estuarine environments. They will look into this further to clarify.

EC-18: *Section 1.3 Thresholds for Incidence Rates of Lesions. The report recommends that a threshold level of 12% liver tumour prevalence (same as the external tumour criterion) should be used, however Environment Canada does not agree with this recommendation. The recommended criterion seems to be set too high. The CLAW team seems to base its recommendation on two papers by Baumann et al. (1996 and 1999). Environment Canada reviewed the papers and Baumann et al. (1999) used an incidence rate for impairment when liver tumour prevalence was ≥5-7%. Furthermore, when Baumann et al. (1996) was reviewed, the paper stated that hepatic neoplasm prevalence above ~5% should be interpreted as an indicator of environmental degradation. The CLAW team seems to have recommended a threshold of 12% partly because of a statement of a "gray area" in the Baumann et al. (1996) study, however it explained that such variability may be the result of highly localized contamination at reference sites, avoidance by fish of contaminated area due to sediment toxicity and environmental extremes, or mobility of fish between tributaries or embayments. The paper continues to state that all sites having liver neoplasm prevalence in bullhead of > 9% are known to be contaminated with chemical carcinogens. Furthermore, the conclusion of this paper was that hepatic neoplasm prevalence above approximately 5% should be interpreted as an indicator of environmental degradation*.

Reviewing some of the literature, it seems that a 5% prevalence criteria for liver lesions is typically used. Furthermore, a recent publication by Baumann et al. (2010) found that brown bullhead in the combined reference data base had a liver neoplasm prevalence of 1%. The Baumann et al. (2010) article states that "this is considerably lower prevalence than the 5% figure from Baumann et al. (1996) which was not unexpected, given the much expanded data base of cancer surveys in Great Lakes fish in the last fifteen years". Taking into account the literature, a threshold of 12% incidence for liver lesions seem to be set too high and a 5% incidence rate should have been used.

EC-18 Response (Category 2): This would be a good item for conference call discussion. The degree of lesion incidence that would be considered acceptable is an issue of protection goals and should be considered at a harbour-wide level. Use of a 5% incidence rate, based on the data summarized in Figure 5, does not allow for distinguishing of background rates from those influenced by organic contaminants.

EC believes that a 5% prevalence rate for liver tumours should be used. The Great Lakes Commission (2002) states that: "*The prevalence of hepatic neoplasms in excess of 5% should be interpreted as an indicator of environmental degradation*". Furthermore Baumann et al. (2010) indicates that urban areas without any major point sources are expected to have liver neoplasm prevalence of 2% or less. Furthermore, the database for reference sites used in the Baumann (2010) report for brown bullhead (n=701) shows a liver neoplasm prevalence of 1%.

EC-19: *Section 4.0 Implications for Kingston Inner Harbour. The report states that based on the weight of evidence provided in the literature, PAHs are more likely to explain the observed lesions than are PCB's based on the following: Somewhat greater evidence for a toxicity mechanism for PAHs, given the extensive laboratory work shown to elicit lesions in bullhead and other bottom fish following exposure to PAHs; More field evidence of empirical associations of PAHs with lesions and tumours; and Environmental concentrations of PAHs in KIH sediments that correspond well to the concentrations identified as having elevated potential to increase tumour prevalence. Environment Canada would like to point out that the first two bullets are based on the fact that PAHs have been studied more extensively then PCBs, however, the fact that PCBs have been less extensively researched does not mean that PCBs may not play an important role in eliciting the types of lesions observed in bullheads*.

EC-19 Response (Category 2): We disagree with the assertion that the evidence for causality of PAHs come solely from the level of research undertaken. Rather, the degree of mechanistic understanding for PAHs is greater, and the empirical data support PAHs as having a stronger relationship to incidence of tumours and lesions. Although we acknowledged the potential role of PCBs, the weight of evidence is much weaker. Baumann (2013) emphasizes that "the evidence linking liver cancer in fish to PAHs is quite extensive" and cites numerous types of field and laboratory studies that provide the basis for this conclusion.

No further comments. We agree with rational that has been presented.

EC-20: *Section 4.1 Exposure Benchmarks. The report proposes benchmark based on the literature assessment that they have undertaken. It proposes: Total PAH of 4 mg/kg (low risk) and 15 mg/kg (moderate risk). Given the data provided in Figure 5, the low risk benchmark seems reasonable, however the 15 mg/kg benchmark for moderate risk seems to be set too high if a 5% prevalence criteria for liver lesions is used. This benchmark should be reviewed and modified accordingly*.

EC-20 Response (Category 2): This would be a good item for conference call discussion. We selected the benchmarks to represent a range of risk levels, reflecting different levels of conservatism. In Baumann (2013), which was not available at the time of our review, an evaluation of the strength of evidence for chemical-induced lesions/tumours was assessed for St. Marys River White Sucker. The author renders the following conclusion:

"In my expert opinion, I believe that 10 ppm total PAH would be a marker above which significantly elevated tumour rates are likely."

This has relevance, both in terms of the strength of the comment (i.e., linkage to PAHs strong enough to support a numerical threshold), and also in the magnitude of PAH concentration suggested. Our suggested benchmarks straddle this proposed level for another Great Lakes site. A disclaimer to the above is that the report was prepared by a consultant and reflects his professional opinion; the report is currently under review by Environment Canada and the Ontario MOE.

Fifteen mg/kg of total PAH for a moderate benchmark seems to be set too high. Taking into consideration the newest work by Baumann et al. (2013) and referring to Figure 5 of the Fish Literature Assessment, a total PAH (High Risk) 10 mg/kg benchmark is more appropriate.

EC-21: *Total PCB of 300 µg/kg (low risk) and 1000 µg/kg (moderate risk). Environment Canada does not agree with these benchmarks. Given the data provided in Figure 7, both the low risk and the moderate risk benchmarks seem to be set too high if a 5% prevalence criteria for liver lesions is used. The PCB benchmarks should be reviewed and modified accordingly*.

EC-21 Response (Category 2): This would be a good item for conference call discussion. Use of a low prevalence criterion, combined with an assumption that PCBs are causally linked to the observed responses, would yield a high chance of a false positive determination. In reviewing Figure 7, an important consideration is that PCBs and PAHs are intercorrelated, such that elevated incidences at 300 µg/kg (or lower) are likely to be due to co-contamination by PAHs.

Currently EC can only state that based on Figure 6 of the Fish Literature Assessment, the benchmarks seems to be set too high. EC will try to contact some of its experts in this field to get a better understanding of the evidence linking liver cancer in fish to PCBs and provide any findings back to Golder.

EC-22: *Section 4.3 Conclusion. It is stated that "PCB's remain a contaminant of potential concern for elicitation of fish deformities. However, the recently compiled sediment chemistry data indicate that the southwestern portion of KIH, rather than Parks Canada water lot, exhibits greater risk potential for this biological endpoint. This conclusion is rendered based on the spatial extent and magnitude of PCB contamination in relation to effects benchmarks". It is true that there is a greater extent of higher concentrations of PCBs in the southwestern portion of KIH compared to the Parks Canada water lot however, risk in the Parks Canada water lot could still be in the moderate range, depending if the benchmark for PCB's are re-examined and values adjusted. When PAHs are considered, it looks like there are higher sediment concentrations in the Parks Canada water lot*.

EC-22 Response (Category 2): We agree that portions of the Parks Canada waterlot may warrant management based on PAHs and/or PCBs. The purpose of the statement was to convey that the spatial extent of substances at potential levels of concern is greater in southwestern portion of KIH compared to the Parks Canada water lot. Both spatial extent and magnitude of risk need to be considered for health indicators related to fish, which are mobile and integrate their exposures.

EC-23: *If the benchmarks are reviewed and modified it would also be recommended to modify the legend in Figure 2 and Figure 3 to have narrower categories of concentrations to better reflect the modified benchmarks*.

EC-23 Response (Category 2): Yes, depending on what the effect benchmarks of interest are, the use of categories could be adjusted as well. That said, the level of precision in the smoothed contours needs to be considered; small differences cannot be reliably estimated using inverse-distance weighting of coarse coverages. Note that we are currently refining the density of sampling points in the southwest KIH, as part of follow-up work for PWGSC.

EC-24: *On p. 12/13 it seems that the wrong figure (Figure 2) is referenced in the bulleted section for Total PAH as well as Figure 5 in the total PCB bulleted section*.

EC-24 Response (Category 1): Yes, typo in Figure reference.

EC-25: *It is recommended to include additional information in Table 1 such as the value used to populate the graphs and the prevalence of deformities found in reference sites*.

EC-25 Response (Category 1): We suggest providing the compiled data spreadsheet instead (more useful).

References

Baumann PC. 2010. *Data Analysis and Fish Tumor BUI Assessment for the Lower Great Lakes and Interconnecting Waterways*. Prepared by Paul C. Baumann, submitted to Environment Canada.

Baumann PC. 2013. *Liver Tumor Prevalence in St. Marys River White Sucker: A Discussion of Probable Causes*. Prepared by Dr. Paul C. Baumann, under contract to Environment Canada. March 31, 2013; revised July 28, 2013.

Ontario Ministry of the Environment, Environment Canada. 2008. *Canada-Ontario Decision-Making Framework for Assessment of Great Lakes Contaminated Sediment*. Prepared by Peter Michael Chapman on behalf of Environment Canada and the Ontario Ministry of the Environment under the Canada Ontario Agreement (COA 2002).

Great Lakes Commission. 2002. *An Overview of U.S. Great Lakes Areas of Concern*. Prepared by the Great Lakes Commission under a cooperative agreement with the U.S. Environmental Protection Agency Great Lakes National Program Office.

Watson-Leung T. 2004. *Laboratory Sediment Toxicity and Bioaccumulation Tests – Report on Cataraqui River Sediments – 2002*. Technical Memorandum prepared for Nadine Benoit (Environmental Monitoring and Reporting Branch) by Trudy Watson-Leung (Ontario Ministry of the Environment, Laboratory Services Branch, Etobicoke, Ontario).

Environment Canada   Environnement Canada

Golder 2014 – review comments

August 1st, 2014

Jennifer Hughes
Senior Environmental Officer
Transport Canada – Ontario Region
4900 Yonge Street
North York, Ontario M2N 6A5

Dear Jennifer,

Subject: **Peer Review Comments for:**
Transport Canada Waterlot Sediment Investigation – 2013.
Kingston Inner Harbour, Kingston, Ontario (March 27, 2014)

Environment Canada has received and reviewed the reports titled "*Transport Canada Waterlot Sediment Investigation – 2013. Kingston Inner Harbour, Kingston, Ontario (March 27, 2014)*" pprepared by Golder Associates Ltd. The review was completed as per our role as an expert support department under the Federal Contaminated Sites Action Plan (FCSAP). Please see our attached comments.

Please contact Maria Petrou if you have any questions with respect to these comments.

Maria Petrou (416)739-4843, Maria.Petrou@ec.gc.ca

cc : Angela Li-Muller, Health Canada
Tara Bortoluzzi, Department of Fisheries and Oceans
Jody Willis, Department of Fisheries and Oceans
Anita Wong, Environment Canada
Rui Fonseca, Environment Canada
Jesica Moreno-Colacci, Environment Canada

Environment Canada – FCSAP Expert Support Peer Review Comments

Site: Kingston Inner Harbour
Report Title: *Transport Canada Waterlot Sediment Investigation – 2013. Kingston Inner Harbour, Kingston, Ontario"* (March 27, 2014)
Prepared By: Golder Associates Ltd.
Prepared for: Transport Canada
Date Reviewed: August 1st, 2014
Reviewed by: Environment Canada - Maria Petrou, Maria.Petrou@ec.gc.ca, 416-739-4843

One of Environment Canada's expert support roles within the Federal Contaminated Sites Action Plan (FCSAP) is to provide advice and information on contaminated sites management to the custodians of Federal contaminated sites. The following comments are provided in response to the report listed above and are for your consideration.

General Comments

Environment Canada has not reviewed previous Transport Canada studies by Golder referenced in this report and cannot comment on the conclusions drawn from them. Also, as this particular sediment study has been conducted in order to fill gaps from such previous studies in the Kingston Inner Harbour by Golder, Environment Canada cannot comment on whether the identified gaps or areas identified for remediation (FF0, MF1 and MF2) are appropriate, or other such conclusions drawn from previous studies. The context of this study is limited and is not incorporated as part of this review. The focus of this review is on the specific results and interpretation from this sediment study alone.

It is imperative that data used to characterize contamination in the harbour be representative of current conditions. Data collected prior to dredging or remediation activities should not be used without confirmation that it is representative of current conditions. Please note that dredging took place in 2004-2005 near the Emma Martin Park to address PCB contamination (Benoit and Burniston, 2010). Other activities may have also occurred.

There is concern of the level of protection of aquatic life drawn in the conclusions. Benchmarks for PAHs and PCBs used as 'low' and 'moderate' risk are set too high and need to be revisited. Methodologies used for organic carbon normalization do not clearly demonstrate how their level of protection is equal to or less than the level of protection that is inherent in the CCME guidelines for sediments.

Introduction

The introduction and context of this study is limited. Specific information such as background on what is understood of the harbour prior to this investigation – especially the area under investigation, the basis of conclusions drawn from previous studies, how the data gaps were identified to move forward with this study, and what specific findings are required to fill in these gaps would be beneficial and recommended to include in this study.

Methods

Please include samples taken from FF-1 in the Field Sampling and Analysis section (page 3, section 2.2). There are three additional samples (Grab 18, 19, and 20) not accounted for. Also, please provide rationale as to why there were no core samples taken in the FF-1 area.

Sediment Chemistry Results

The report indicates that data used to generate the surface chemistry maps shown in figures 1-8 are compiled from data collected in the years 2003-2013 (page 5, section 3.0). References should be provided to indicate the sources of this data. In addition, screening methods on how this data was selected and validated as appropriate and representative of current conditions should also be included. It is imperative that data used to characterize the contamination in the harbour be representative of current conditions as site management and remediation decisions are based on this information. Data collected prior to dredging or remediation activities should not be used without confirmation that it is still representative of current conditions. Please note that there has been dredging activities in 2004-2005 near the Emma Martin Park to address PCB contamination (Benoit and Burniston, 2010). Other activities may have also occurred.

Environment Canada does not agree with the PAH and PCB benchmarks presented for low and moderate risk (page 6, section 3.0) that are incorporated in the figures and used to draw conclusions. These benchmarks are set too high. Environment Canada believes that concentrations of 10 ppm total PAH are a marker above which significantly elevated tumor rates are likely (Baumann 2013). Furthermore, a 5% prevalence rate of liver tumours should be interpreted as an indicator for environmental degradation (the Great Lakes Commission 2002) and prevalence of liver neoplasms in urban areas without any major point sources are expected to have liver neoplasm prevalence of 2% or less (Baumann 2010). In addition, the benchmarks presented in this report use external and liver lesion incidence rates interchangeably, however their occurrences are not one in the same. There are strong correlations found with liver neoplasms and PAH specifically; external lesions are not as strongly correlated and are subject to various confounding factors (such as viruses and injury). The benchmarks, as well as the figures and conclusions drawn using these benchmarks need to be revisited.

The Organic Contaminants section 3.2 on page 8 concludes that surface sediment PCB data collected in 2013 are not expected to be sufficiently high to exhibit toxicity to benthic invertebrates based on suggestions of the SQG derivations. Please provide a clear reference to which SQG derivations and publications are being referred to and how exceedances of CCME Probable Effects Levels can be dismissed based on these findings. Furthermore, as noted in the comments above regarding benchmarks, the "moderate risk' benchmark for PCBs set for 1.0 mg/kg needs to be revisited and should not be used to draw conclusions that toxic effects suggest '*a modest potential for increased tumor prevalence in fish*'.

Similarly, moderate risk benchmarks for PAHs, as referred to on Page 8, section 3.2 need to be revisited.

The results presented in Table 1 show CCME PEL and PSQG-Ontario SEL exceedances of lead throughout all areas under investigation (FF0, FF-1, MF1, and MF2) and of mercury throughout most of the areas under investigation (FF0, MF1, and MF2) however there is no mention of this in the summary of results. These are fairly pronounced and consistent exceedances. Please explain the significance of these findings and the implications they have on future decisions and site management requirements.

Copper exceedances were prevalent in FF0 as shown in Table 1. These exceedances were explained in the results as possibly caused by current and historic use of antifouling paints used on boat hulls. As this is a possible on-going source, should the extent of ongoing contamination and impacts to the harbour be further investigated and addressed – if required – prior to any remediation activity?

Detection limits for several parameters (mainly PAHs and PCBs) are greater than the guidelines. The report should identify where these occur, how results below detection limits are interpreted, and how they affect the conclusions of the study.

Figure10 "*Proportions of Individual PAH Components Relative to the Total of 2-, 3-, 4- and 5-ringed PAH groups and to the Site Total PAH Concentration for Anglin Bay Areas Sites*" as mentioned in the list of figures and on page 12, section 4.2, is missing from the report.

Organic Carbon Normalization & Bioavailability Assessment

Environment Canada (1998) has been referenced on page 5, section 2.3.1.2 however it is not listed in the reference section. Please include this reference and how it pertains to Environment Canada's most current stance on PAH bioavailability.

Subsequent to the Treasury Board Policy of Management of real Property (section 6.1.12), FCSAP considers acceptable risk to be any risk that is equal to or less than the level of protection that is inherent in the CCME guidelines. For sediments in particular, this is to protect all forms of aquatic life and all aspects of the aquatic life cycle. Generally speaking, sediment concentrations must be below which adverse effects rarely occur. It is unclear how the use of organic carbon normalization provides an equivalent level of protection to CCME guidelines. If this approach is to be adopted, specific reference to the methodology used must be provided as well as a clear explanation and rationale as to how the level of protection is maintained by using guidelines and methodologies of another jurisdiction when CCME guidelines are already available.

Source Investigation

The results summarized for the storm sewer runoff investigation provide a general overview of the study's findings however more detail would be beneficial and recommended. For example, figure 2 provides a map of the entire harbour; a more appropriate representation would be of a map specific to the area under investigation as well as the location of the storm sewer discharge and the location of historical sources. As shown, it is not clear how the conclusions are validated.

Conclusions

Environment Canada cannot provide specific comments to the conclusions provided in this study, as analysis methods and benchmarks used within the current study need to first be addressed.

Please specify what contamination is referred to in the following sentence (page 13, section 5.0): "*Results of this investigation also further confirm the conclusions of the source evaluation (Golder 2013a) that historical (legacy) sources, rather than ongoing sources, are primarily responsible for the observed pattern of sediment contamination in the Transport Canada water lots of KIH*".

Next Steps

Environment Canada cannot comment on the specifics on the 'next steps' required as previous reports and findings have not been reviewed.

Moving forward, an appropriate step would be for Transport Canada can to work collaboratively with the other federal custodians of the Kingston Inner Harbour (Parks Canada, and Department of National Defence) to address data gaps and achieve a comprehensive understanding of the harbour for all federal properties as well as avoid duplication of effort.

Environment Canada provides these comments as per our role as Expert Support for the Federal Contaminated Sites Action Plan (FCSAP). This advice is not intended to replace your own independent scientific, technical and legal advice as to how to establish your own contaminated site risk management plan, how to remediate your contaminated site, or comply with federal or provincial environmental law. Environment Canada assumes no responsibility or liability regarding any decisions you make as to how you comply with that law.

References

Baumann PC. 2010. *Data Analysis and Fish Tumor BUI Assessment for the Lower Great Lakes and Interconnecting Waterways*. Prepared by Paul C. Baumann submitted to Environment Canada.

Baumann PC. 2013. *Liver Tumor Prevalence in St. Marys River White Sucker: A Discussion of Probable Causes. Prepared by Dr. Paul C. Baumann, under contract to Environment Canada.* March 31, 2013; revised July 28, 2013

Benoit, N. and D. Burniston 2010. *Cataraqui River Project Trackdown: Follow-up study on success of remediation efforts in the Cataraqui River 2006*. Prepared for the Eastern Region of the Ontario Ministry of the Environment, April 2010

Great Lakes Commission. 2002. *An overview of U.S. Great Lakes Areas of Concern*. Prepared by the Great Lakes Commission under a cooperative agreement with the U.S. Environmental Protection Agency Great Lakes National Program Office.

TECHNICAL MEMORANDUM

DATE January 12, 2015 **PROJECT No.** 1416134

TO Javier Banuelos
Public Works and Government Services Canada

CC Health Canada (Meghan Roushorne and Viktors Kulnieks); Environment Canada (Maria Petrou); DFO (Tara Bortoluzzi); Transport Canada (Jennifer Hughes); Golder Associates (Mike Z'Graggen, Shawn Seguin)

FROM Gary Lawrence **EMAIL** glawrence@golder.com

DRAFT RESPONSES TO THE FCSAP EXPERT SUPPORT COMMENTS ON KINGSTON INNER HARBOUR 2014 REPORTING PACKAGE

1.0 INTRODUCTION

This memorandum summarizes and responds to feedback received from FCSAP Expert Support related to risk assessment deliverables for the Kingston Inner Harbour sediment assessment (*Application of the Canada-Ontario Decision-making Framework for Contaminated Sediments in the Kingston Inner Harbour*). Comments were provided as three sets of written responses, each provided to Jennifer Hughes of Transport Canada:

- Health Canada (Viktors Kulnieks; June 27, 2014);
- Environment Canada (Maria Petrou; June 27, 2014); and
- Fisheries and Oceans Canada (Tara Bortoluzzi; July 8, 2014).

Our response is divided into: (1) a general summary of feedback as overall themes; and (2) specific responses to all technical comments received. The latter responses also include a partitioning of comments into categories to help streamline the process for responding. This partitioning will help to focus liaison with Expert Support on those issues that are unclear, contentious, or that require further discussion.

- **Category 1** – Technical feedback that is being addressed directly, either directly in this response memo (Category 1a) and/or through incorporation of feedback in the Risk Assessment Consolidation and Refinement deliverable (Category 1b). This category focuses on simple matters and procedures for which extensive consultation is not likely to be required.
- **Category 2** – Comments of a technical nature that we believe require liaison with Expert Support, including issues of interpretation, suggested major revisions, or differences in professional opinion. From an examination of FCSAP comments there are some issues for which multiple approaches are possible to address the comment, and for which agreement should be sought before preparing future reports.
- **Category 3** – Comments that may require broader consultation beyond Expert Support (i.e., liaison with stakeholders and site custodians). This category is expected to relate to issues of uncertainty, trade-offs in risk management objectives, feasibility considerations for site custodians, and overall risk tolerance. This category includes items of high importance for site management, but for which consultation with Expert Support may not provide closure.

- **Category 4** – Topic raised is beyond the scope of the risk refinement (i.e., feedback is relevant but relates to future stages of site management), or relates to RMC-ESG deliverable details not within Golder's scope or control.

- **Category 5** – Additional information would be required to address comment (i.e., clarification or provision of raw data from RMC). For such items, we may require the PWGSC technical lead to assist in obtaining the necessary information.

2.0 ECOLOGICAL RISK ASSESSMENT – OVERVIEW OF COMMENTS

Issues identified by Environment Canada and Fisheries and Oceans Canada include:

- Synthesis of sediment chemistry to reflect current conditions – There was a recommendation to exclude data considered too old to reflect current surface sediment conditions, and to assess the representativeness of data collected near the timing of the sediment dredging near Emma Martin Park circa (2004-2005). Related comments pertained to the need to verify inclusion of all relevant PWGSC data, including recent collections not included in the RMC-ESG documentation.

- Define APECs clearly – Several Expert Support comments related to the need to define more clearly the sediment management units, both in terms of the overall study area boundaries and the subunits within the overall study area.

- Spatial averaging methods – Some Expert Support comments questioned the methods used to aggregate exposure to mobile ecological receptors. Issues identified included the size and shape of APECs, potential for recontamination following remediation, and effect of localized exposures (e.g., enhanced through preferred habitat availability, or reduced through hot-spot remediation).

- Characterize ecological effects in spatially explicit manner – several Expert Support comments emphasized the need to consider risk outcomes more clearly linked to subunits of KIH, particularly for wildlife (mammals/birds) and fish. Whereas the assessment has been spatially explicit in the benthic community assessment, the mobile receptors that cross waterlot boundaries require a refined assessment of the home ranges and habitat preferences of these organisms.

- Consider protectiveness of selected receptor species – Several Expert Support comments focused on the potential relevance of wildlife species not explicitly considered in the ERA. For example, muskrat and red wing blackbird were suggested as candidate species for an assessment of nearshore species, and the potential contribution of risks from Orchard Street marsh (via soil contact) was raised. In addition, risks to herptiles and endangered species were raised as uncertainties in the current ERA documentation.

- Incorporate morphological abnormalities in fish – Several Expert Support comments focused on the lines of evidence for fish deformities, including both literature-based evaluations and the field surveys conducted by RMC-ESG. To date, these results have not been linked to risk assessment outcomes in a quantitative manner (i.e., not linked to SeQOs).

- Exposure assumptions for wildlife – Some Expert Support comments focussed on specific parameter choices, such as dietary assumptions for mink and mallard, or other technical approaches that influence hazard quotients, such as spatial averaging and receptor home ranges. The modelling uncertainty for food web transfer pathways was also raised as a concern.

- Causation assessment – Some Expert Support comments questioned some of statements made in the RMC-ESG documents with respect to available evidence for causation, and the need to understand causative linkages at the risk management stage.
- Sediment stability assessment – Multiple Expert Support comments commented on the need to better understand sediment stability prior to remedial option evaluation.
- Screening-level versus detailed-level evaluations – Some comments emphasized confusion regarding whether risk characterization findings were based on conservative (screening-level) risk estimates or alternatively were based on more refined or site-specific risk estimates. This influences the manner in which hazard quotients are interpreted.
- Consider all risk pathways – Expert Support concluded that the RMC-ESG documentation inappropriately emphasized certain risk pathways, while excluding others, in summarizing the overall risk of sediment related contamination.

We found the Expert Support Comments to be valuable and worth addressing in the next stage of reporting. There are some issues for which liaison (via teleconference) would help to frame the path forward.

3.0 HUMAN HEALTH RISK ASSESSMENT – OVERVIEW OF COMMENTS

Health Canada has reviewed the RMC-ESG (2014) reporting package and determined that the HHRA (Chapter IV) and management options analysis (Chapter V) should be refined in recognition of some significant technical issues, particularly as "some comments are significant in nature and thus may impact the interpretation of the HHRA and any decisions stemming from it." General issues identified by Health Canada include:

- Selecting and screening of COPCs – Although RMC-ESG captured the primary substances of concern in the HHRA, Health Canada has requested additional rationale or more formal screening to identify whether additional substances should have been retained for formal evaluation (e.g., volatile organics or additional metals).
- Reference area evaluation – Health Canada has highlighted the need for a clear rationale for defining the area upstream of Belle Island as a reference area, which echoes comments received from Environment Canada on recent studies in the Parks Canada water lot.
- Define APECs clearly – Similar to Expert Support comments for ecological receptors, there was concern that the exposure profile for the "exposed" portion of KIH below Belle Island was oversimplified, requiring identification of management zones with varying levels of contamination.
- Linkage of fish tissue data to exposure areas – The fish tissue data collected by both RMC-ESG and Golder need to be more clearly linked to the sediment APECs, with consideration given to home ranges and plausible movements of the monitored species. Specific comments were made concerning mercury in fish tissue and associated variability across the study area and/or by fish tissue type.
- Screening procedures for tissue-borne substances – Several specific comments were made regarding the data screening methods for mercury, arsenic, and lead.
- Chromium bioaccumulation – Improved rationale is required for the exclusion of chromium from the HHRA given the elevated concentrations of chromium in environmental samples.

- Exposure point concentrations – Several concerns were raised with the choice of exposure metric used in the HHRA, based on the upper confidence limit of a mean for the entire Site rather than a spatially explicit assessment. Liaison with Health Canada is required to assess spatially averaged exposures that reflect chronic exposure but also recognize localized differences in contamination across the KIH. Although the RMC-ESG report includes "special management areas", such were not applied consistently for all substances and pathways.
- Treatment of "anomalous" data – Concerns were raised with the exclusion of specific data points, including two shallow subsurface antimony data points near the Orchard Marsh and elevated PAHs at depth near Anglin Bay.
- Uncertainty related to lack of assessment for dioxin-like PCBs.
- Uncertainty related to contamination present at depth (i.e., not currently available to organisms, but requiring assessment for long-term management).
- Fish ingestion assumptions – Several comments were made by Health Canada on the exposure scenario, including tissue ingestion rate and amortization of exposure over time.
- Dermal adherence – Several comments related to the rationale for dermal adherence factors, particularly given the importance of this pathway for driving overall risk in the RMC-ESG HHRA.
- Sediment ingestion rates – Health Canada notes the development of recent guidance on sediment ingestion rates for human receptors, warranting consideration in a refined HHRA.
- Toxicity reference values – Refinement of the chlordane and lead TRV assessment was recommended.

Again, the FCSAP Expert Support comments were valuable, and many of these can be addressed in the next stage of reporting. An important step is to liaise with Health Canada on some key assumptions/parameters, focussing on those parameters that exert the greatest influence on risk estimates. From several of the comments on the HHRA, it is apparent that these parameter choices must strike a balance between conservatism (protectiveness), degree of realism, and the uncertainty inherent in defining exposure scenarios for receptor groups both under current conditions and plausible future conditions.

4.0 DFO – FCSAP EXPERT SUPPORT PEER REVIEW COMMENTS

4.1 Part A. Application of the Canada-Ontario Decision-Making Framework for Contaminated Sediments in the Kingston Inner Harbour prepared by the Environmental Sciences Group Royal Military College (February 2014)

DFO-2014-001

[General Comments] • The Area(s) of Potential Environmental Concern (APECs) in KIH is/are not clearly defined in the report. None of the maps included in the report clearly identify the site boundaries. It is unclear whether the APEC(s) referred to in this report encompasses all/part of the Orchard Street Marsh, the Parks Canada water lot, and/or the Transport Canada water lot. A clear picture of the Area(s) of Potential Environmental Concern is needed.

- Response Category 1b

- Response DFO-2014-001 – We agree that defining areas of concern is an important aspect on the risk characterization. We intend to develop revised management zones that combine consideration of property boundaries (Transport Canada, Parks Canada, and others) and that also define transitions in the distribution of exposure and effects data. Our previous reports (PQRA and DQRA) applied a similar breakdown of sediments into management areas; however, a substantial amount of risk assessment information has been obtained since that time, such that reconfiguring the boundaries is warranted. The size and shape of the management units will also consider factors such as distance from shoreline, simplicity for defining potential dredge cuts, and the degree of overlap among contaminant distributions for key constituents. The use of spatially defined APECs does not constrain the development of risk assessment outcomes for receptors that cross spatial boundaries. Rather, the results for management units can be aggregated into larger areas as appropriate, incorporating knowledge of the relative use of each unit (e.g., proximity to shoreline, habitat preferences, etc.).

DFO-2014-002

[Executive Summary] • Fisheries and Oceans Canada is listed as a member of the Cataraqui River Stakeholder Group (CRSG; page iii, paragraph 3). Please note the DFO FCSAP Expert Support teams involvement in KIH is to support and provide technical advice to federal site custodians under the FCSAP framework (i.e. in this case Parks Canada and Transport Canada). DFO FCSAP ES is not a key stakeholder nor is it a member of the CRSG.

- Response Category 4
- Response DFO-2014-002 – This comment, and several similar comments raised by Expert Support, relate to the comments made in the RMC-ESG deliverable concerning the degree of acceptance or endorsement of risk assessment approaches and conclusions. We understand that there are some technical areas for which there has not been consensus or endorsement by the Expert Support departments. Our approach will be to incorporate the technical input of the Expert Support depatments, also acknowledging previous comments from these departments based on earlier draft versions of the RMC-ESG reporting package. It is not our intention to engage the Cataraqui River Stakeholder Group until these technical refinements are complete.

DFO-2014-003

[Executive Summary] • The report states “the five chapters in this report summarize everything that is known about the Harbour” (page IV, paragraph 3). This statement is misleading as there are other available studies, data and information regarding KIH that were not included in this report. Please revise this statement.

- Response Category 4
- Response DFO-2014-003 – We agree that there are other sources of information that provide important contributions to the understanding of risk in the Harbour. The 2014 RMC deliverable attempted to synthesize previous studies with additional information collected on behalf of the custodial departments (Parks Canada, Transport Canada). However, due to the iterative nature of the investigations, additional information continued to become available as the RMC-ESG deliverable was being refined. Some of this information, such as localized presence of elevated PAH concentrations in some sediments adjacent to Anglin Bay, will have a meaningful influence on the overall risk characterization of harbour sediments. At a broader level, there are related statements made in the RMC-ESG reporting package that suggest that the technical investigation was complete by 2013 and that the only remaining steps entailed remedial options evaluation. We do not believe that these statements (opinions) were justified because the investigations have revealed important information on both exposure and effects that rendered final decision-making for sediments in the KIH to be premature.

DFO-2014-004

[Chapter I – Literature Review] • The report notes that "Sediment transport and deposition patterns within the KIH are not well understood but are probably complex, given the hydrological flow constraints and shallow depths. Sediment resuspension from wind and wave action, boating activities and flow patterns appears to be important in redistributing sediments within the harbour" (page III-2, paragraph 4). Before proceeding with any plans for remediation work, the study would greatly benefit from sediment stability assessment to evaluate and better understand critical shear stress for erosion of various areas of contaminated sediments, as well as modeling and prediction of the expected shear stress from wind and water flow driven currents and vessels.

- Response Category 4
- Response DFO-2014-004 – We agree that sediment transport and deposition are an important aspect of the overall project, and have previously identified this issue to site custodians. In particular, the effectiveness and permanence of the overall remedy will be influenced by the redistribution of surface sediments from waves, currents, and mechanical disturbance. We are concerned that the Chapter V recommendations in the RMC-ESG reporting package, particularly concerning the use of narrow buffer zones for management of risks attributable to wading and swimming exposure pathways, do not consider the potential for recontamination from adjacent areas. That said, there is still value is characterizing present-day risks to the various receptor groups, including those that migrate across area boundaries, and then conducting a separate assessment of how various remediation tools will be influenced by sediment stability. For example, if a sediment unit is determined to require remediation, the potential for recontamination will be different using dredging, dredging with backfilling, capping, or enhanced natural recovery. At this stage, we believe that decision-making is best informed by conveying present-day risks for various receptors and pathways, focussing on current near-surface conditions. Following the Canada Ontario Framework, this approach aligns with Decision Point 4; at this stage "definitive determinations are possible in some cases with the proviso that sediment stability may still need to be assessed (Step 7); in other cases, further assessment is needed, but can be guided by the results of this data integration." The assessment of sediment stability would be combined with assessment of contamination at depth, where applicable. Step 7 of the COA Framework considers whether, under unusual but possible natural or human-related circumstances, these deeper sediments may be uncovered, and also whether deposits from adjacent areas will influence long-term exposures at the sediment surface. Therefore, although we agree that sediment stability assessment will ultimately be important for site management, such studies can be conducted following the risk assessment refinement that is currently underway. The results of the risk refinement will help inform which sediment units are of greatest priority for the evaluation of stability.

DFO-2014-005

[Chapter II – Spatial Distribution of Contaminants in Sediments] • The sediment maps include data from 1991 and 2008 (page II-2 and Table II-1). Given the harbour is shallow; the sediments are subject to frequent movement, resuspension, and disturbance. Further some of the sources of contamination have been migrated, for example the study by Benoit and Burniston (2010), referenced in the report, notes that dredging activities previously occurred near Emma Martin Park in 2004-2005 to address PCB contamination. Any data used to characterize contamination characteristics in KIH should be representative of current conditions, and data collected prior to dredging or remediation activities should not be used. However, results of these dredging activities, or any other dredging, remediation, or alternation in KIH should also be discussed in the report.

- Response Categories 1b, 4

- Response DFO-2014-005 – The inclusion of data from 1991 is specific to the RMC-ESG deliverable. However, Golder has also developed a database on surface sediment chemistry information in GIS format, which was used to create surfaces presented in the PQRA and DQRA. This database includes historical investigations plus recent supplemental studies, such as data from toxicity and chemistry studies conducted in the Parks Canada water lot in November 2012 and sediment quality data from southwest KIH collected for Transport Canada in September 2013. In preparing surfaces of sediment quality conditions, we have combined data sets from multiple sampling rounds, and previously (in PQRA and DQRA) used a cutoff of 2003 to distinguish potentially outdated information from data considered to reflect current conditions near the sediment surface. Although we believe that the selection of 2003 represents a reasonable compromise between the considerations of temporal representativeness of data and degree of spatial coverage, we also understand that the dredging program along the western shoreline in 2004-2005 is a special case warranting careful consideration of the representativeness of sediment data. As part of the risk refinement, we will review the samples collected between 2003 and 2005 and will exclude any data points that would represent sediment pockets removed during that program. Sediments sampled between 2003 and 2005 that are beyond the footprint of remediation will be retained.

DFO-2014-006

[Chapter II – Spatial Distribution of Contaminants in Sediments] • The inclusion of site map(s) are needed to better illustrate the locations of sediment sampling sites in the 'Contaminated' APEC and 'Reference' sites used in the data analysis, tables and figures.

- Response Category 1b
- Response DFO-2014-006 – Although this comment was directed to the RMC-ESG 2014 reporting package, it has relevance to the forthcoming risk refinement deliverable. We intend to convey sediment quality data in relation to both legal lot boundaries and management units (i.e., APECs). Some of the figures will emphasize conditions downstream of Belle Island (i.e., the area defined by RMC-ESG to be the "contaminated" area). We are in agreement with RMC-ESG that the sediments north of Belle Island and the Transport Canada water lot generally provide a suitable reference condition for comparison with the downstream areas.

DFO-2014-007

[Chapter II – Spatial Distribution of Contaminants in Sediments] • All the figures and tables should include the date(s) samples were collected.

- Response Category 1b
- Response DFO-2014-007 – Although this comment was directed to the RMC-ESG 2014 reporting package, it has relevance to the forthcoming risk refinement deliverable. Our previous reports, such as the Transport Canada waterlot sediment investigation (March 27, 2014), included contamination distribution figures that labelled all individual stations with Sample IDs. However, due to the number of density of sampling points, it is not practical to also label sampling date or other details (such would not be legible). Instead, we can explore the use of coded symbols, font types, or other means of distinguishing sediment quality data from different years.

DFO-2014-008

[Chapter II – Spatial Distribution of Contaminants in Sediments] • The Boxplot Figures should include p- and r2 - values to indicate the statistical significance of the difference in the concentration of COPCs between 'Contaminated' and 'Reference' sites.

- Response Category 4
- Response DFO-2014-008 – Relates primarily to RMC-ESG reporting, although the comment is acknowledged in terms of providing details of any statistical comparisons between exposed and upstream reference conditions.

DFO-2014-009

[Chapter III – Ecological Effects] • The executive summary indicates the results of the sediment investigations show 'consistent evidence of ecological effects for benthic communities in the southern portion of the harbour" (executive summary, page ii); however this is not consistent with the overall results of the chapter which show mixed, inconclusive or no evidence of effects across KIH. For example the report states "The assessment of toxicity in the southwestern KIH is complicated by conflicting results between co-located sediment samples tested by Cantest and Environment Canada for some test locations" (page III-8, paragraph 1), and "Overall, the available studies indicate negligible toxicity for areas north of Belle Park and for the central and eastern portions of the southern KIH. There is mixed evidence for benthic invertebrate toxicity in the southwestern portion of the KIH" (page III-8, paragraph 3). The conclusions reached in this chapter are unclear and need revision.

- Response Category 1b
- Response DFO-2014-009 – Although this comment was directed to the RMC-ESG 2014 reporting package, it has relevance to the forthcoming risk refinement deliverable. We agree that Chapters III and V present an unclear summary of the ecological significance of benthic community conditions, sometimes suggesting evidence of impact and at other times discounting results from the assessment of invertebrates. This confusion arises from two elements of the documentation. First, the lack of spatial specificity in the conclusions means that the narrative for benthic communities oversimplifies results that cover a wide range of conditions and findings. In this regard, we intend to use refined management zones to convey that benthic community results differ across the lower KIH, using a weight of evidence framework to distinguish between stations and zones indicating meaningful impairment from those that do not. Second, the RMC-ESG narratives have in some cases blurred the distinction between the scientific outcomes of the studies and the stakeholder consultations from June 2010. Although it may be appropriate to incorporate stakeholder input as part of the overall remedial options analysis, the presentation of risks to each receptor group must be conveyed transparently and objectively before any value-based assignments are made. The latter point has been confirmed in subsequent FCSAP Expert Support Comments.

DFO-2014-010

[Chapter IV – Ecological Risk Assessment (Section III)] • It is unclear why macrophytes and benthic invertebrates were excluded from the risk assessment. Toxicological data are available to assess the risk to these organisms. If these organisms are excluded from the risk assessment, clear rationale should be provided.

- Response Category 1a

- Response DFO-2014-010 – We believe that the reviewer's confusion is related to the reporting structure in the RMC-ESG 2014 reporting package. RMC-ESG partitioned the evaluation of the lower trophic levels (benthic invertebrates and aquatic plants) from the evaluation of human health and wildlife (birds, mammals). Therefore these receptor groups were not excluded from the overall risk assessment package, but rather partitioned into two separate HHERA chapters. In some respects this approach makes sense because the types of tools applied in each chapter differ between these groups. For example, the human health and wildlife assessments rely on a hazard quotient approach (i.e., comparison of dose to toxicity reference value) whereas the benthic community assessment applies a weight-of-evidence analysis. The fish receptor group is more complicated because the bioaccumulation aspects are covered in Chapter III whereas the assessment of fish health is covered in Chapter IV. The RMC-ESG assessment considered both macrophytes (and cattails) and benthic invertebrates in Chapter III; the former were used primarily as an indicator of bioaccumulation/biomagnification potential. However, Chapter I of the RMC-ESG report also documents information on macrophyte community structure, including work by the Royal Military College documenting that communities did not appear to be related to sediment contamination. Overall, we believe that RMC-ESG have presented sufficient evidence that macrophytes can be excluded from consideration as a sensitive receptor group.

DFO-2014-011

[Chapter IV – Ecological Risk Assessment (Section III)] • While reptiles and amphibians were included in the Conceptual Site Model (CSM), they were not included in the final risk assessment. Several turtles, snakes and frogs were observed during a site visit to Kingston Inner Harbour on June 4th, 2013. Further the chapter notes that numerous reptiles and amphibians inhabit the APEC (page III-11 and III-12), and Chapter I (literature review) notes that "sixteen species of reptiles and amphibians have been observed in KIH," including species at risk (page III-21, paragraph 4). Amphibians and reptiles should be considered potentially sensitive receptors requiring further consideration in the risk assessment; If not additional rationale (other than a lack of toxicological information) should be provided as to why these receptors have not been further considered.

- Response Category 1b
- Response DFO-2014-011 – The assessment of herptiles is challenging based on both the scarcity of toxicological information and the complexity of the exposures of these animals (i.e., combination of aquatic and terrestrial exposure that is linked strong to life stage). However, we agree that some evaluation of these receptors should be provided, even if the uncertainty is large relative to fish and benthic invertebrates. Our scope and schedule for the risk refinement does not allow for a site-specific toxicological evaluation; however, some information is available from the literature that would help to inform a qualitative or semi-quantitative assessment for these species. For example, sediment benchmarks for PCBs have been developed at other sites (e.g., Housatonic River MA). Information on the relative sensitivity of herptiles, invertebrates, and other organisms may also be available to provide insight on the degree of protection provided by SeQOs based on a limited representation of species. This information will be considered in the risk refinement document.

  Note that the scope of the assessment is constrained to the water lots under the jurisdiction of the federal custodians. Therefore, although habitat for reptiles and amphibians may exist on the upland portions of the harbour (e.g., Orchard Street marsh soils), the purpose of this risk assessment is only to evaluate receptors with exposures overlapping the water lot sediments. Accordingly, risks associated with soil-driven pathways linked to upgradient brownfields will not be considered as part of the risk refinement.

DFO-2014-012

[Chapter IV – Ecological Risk Assessment (Section III)] • While it is noted Chapter I (literature review) that aquatic species of risk (SARA) are found in KIH (page III-15, paragraph 1), no species at risk were evaluated in the risk assessment (i.e. fish, amphibians). Any species at risk that use or frequent KIH should be included in the risk assessment. If not additional rationale (other than a lack of toxicological information) should be provided as to why these receptors have not been further considered.

- Response Category 1b
- Response DFO-2014-012 – The list of species of special concern mentioned in Chapter I includes the entire Kingston Inner Harbour, including areas north of Belle Island such as the Great Cataraqui Marsh that are designated as provincially significant wetlands. In contrast, the habitats south of Belle Island in the vicinity of former and current industrial and commercial land uses would have a subset of the species documented for the entire KIH. However, the point made concerning the need to describe risks to species of special concern is valid. We recommend refining the list of species of special concern to include only those identified in the lower portions of KIH (such as in the species inventory and ecological evaluation of the Orchard Street Marsh in 2008). Next, the risk assessment results for the receptors formally included in the RMC-ESG wildlife risk assessment can be evaluated for relevance to these additional species. By comparing the life history attributes (e.g., diet, home range, habitat preferences) some qualitative information on risk to species of special concern can be obtained. Furthermore, because the existing risk assessment results for wildlife have been developed based on assessment of risk to individuals (rather than populations or communities), the methods are transferable to assessment of listed species.

DFO-2014-013

[Chapter IV – Ecological Risk Assessment (Section III)] • The report notes that TRVs used for the fish tissue residue study were not appropriate for brown bullhead or other piscivorous fish (page III-37). Given the resultant uncertainties with this approach, COPC toxicity thresholds may need to be uniquely determined for each fish species and varying exposure pathways and site specific hazard quotients may need to be reconsidered.

- Response Category 1b
- Response DFO-2014-013 – The comments made by RMC-ESG regarding the perceived limitations of tissue-based TRVs for fish were intended to explain why observed effects in bottom fish might be possible even when observed tissue concentrations do not exceed literature-based benchmarks. Although there are some uncertainties with extrapolating benchmarks across species and habitats, there is a more fundamental issue here. The benchmarks considered by RMC-ESG considered only PCBs and a few metals/metalloids (arsenic, copper, lead, zinc, mercury) and only considered tissue-based benchmarks. Before speculating on the ecological relevance of these thresholds to bottom fish, it is necessary to consider other risk pathways not captured by this tissue screening. The most obvious oversight in this evaluation is PAH exposure to bottom fish, which is not captured by tissue-based screening (because PAHs are readily transformed into metabolites by teleost fish). Golder has conducted an evaluation of sediment-based benchmarks for protection of bottom fish from various abnormalities, and has concluded that some areas of KIH exceed concentrations shown to elevate tumour prevalence at similar sites.

  To address the Export Support Comment, we agree that additional information is required to support the assessment of individual COPC risks to fish. Both tissue and sediment benchmarks can be considered as appropriate and used to support a weight of evidence for risks to fish. Rather than abandon the fish health pathway (i.e., Chapter V does not develop SeQOs for this pathway, opting instead to assume that remediation for other purposes will appropriately improve the environmental conditions), our approach will be to carry forward benchmarks for both tissue- and sediment-based benchmarks for the protection of fish health. The strengths and uncertainties of these evaluations can then be evaluated as part of the weight-of-evidence.

DFO-2014-014

[Chapter IV – Ecological Risk Assessment (Section III)] • Deformities, lesions and tumors in brown bullheads were used as a measurement endpoint of fish health (page III-16, paragraph 5). The causes of these deformities were speculated to be a cause of the interaction of chemical mixtures within the sediments resulting in additive and/or synergistic effects (page III-35 to III-37). Other studies have shown that COPCs can interact in aquatic environments resulting in synergistic ecological effects. The report would benefit by further elaborating and including further literature references regarding their concerns of increased toxicity to fish from combined COPCs in KIH, particularly PAHs and other COPCs. Please see Gauthier et al. (2014) for recent references.

- Response Category 1b
- Response DFO-2014-014 – See response to comment DFO-2014-013. Although we agree that interactions among sediment-associated substances are possible, the discussion of physical abnormalities provided in Chapter IV and Chapter V does not, in our opinion, appropriately convey the degree of uncertainty in the assessment of respective contaminant groups. Although there is uncertainty for all individual contaminants and in their interactions, the weight of evidence from the assessments of bottom fish deformities in Great Lakes fish indicates that organic contaminants (primarily PAHs, with possible contribution of PCBs) are the primary risk drivers for bottom fish deformities.

  To respond to the Expert Support comment, we intend to incorporate the results of our review of bottom fish deformities (including benchmarks developed from those studies) and also consider the findings of Gauthier et al. (2014). An assessment of the potential interactions among contaminant groups will be included.

DFO-2014-015

[Chapter IV – Ecological Risk Assessment (Section III)] • Since the toxicity threshold fish tissue residue data did not agree with the presence of deformities, are remediation options also taking into account fish abnormalities? Any future studies should include evaluation of PAH toxicity with respect to fish tissue concentrations.

- Response Categories 2 and 3
- Response DFO-2014-015 – Our opinion is that the remediation options should take into consideration what is known about fish abnormalities, including the evidence for likely causes and a range of benchmarks. The uncertainties inherent in the benchmarks derivations should also be taken into account. In our opinion, the most reliable basis for benchmark derivation comes from comparison of sediment concentrations to the presence of elevated deformity rates at other Great Lakes sites. Prior to incorporating this information in the development of the risk refinement deliverable, we would like to discuss with Expert Support an appropriate means of integrating this information with other lines of evidence (e.g., acceptable rate of deformities, how to account for multiple causative agents in SeQO development).

  This issue has also been flagged as Category 3 because the environmental protection goal for deformity incidence has not been clearly defined, and as such, broader consultation may be needed to determine the importance/weight that should be assigned to this endpoint (for overall risk characterization and remediation planning). Presence of deformities on bottom fish is less clear cut as an effects measure in an ecological risk assessment relative to survival, growth, reproduction, and developmental effects. There is also some indication by RMC-ESG that the Cataraqui Stakeholder Group has offered an opinion on the importance of this risk pathway relative to protection of human health and wildlife. Finally, even if the endpoint is assigned equal importance to other effects measures, the issue of acceptable magnitude of response (i.e., degree of elevated incidence relative to regional background) remains.

DFO-2014-016

[Chapter IV – Ecological Risk Assessment (Section III)] • Many aspects of the risk assessment are largely based on modelling, however much of the modelling does not include validation or calibration. While it is recognized that validation and calibration is not possible for all aspects, whenever possible any models used should validated with ground truthing.

- Response Category 4
- Response DFO-2014-016 – We agree with the comment, which applies to the RMC-ESG deliverable, and presumably relates to the bioaccumulation models used to link sediment concentrations to tissue concentrations (and dietary intake). That said, it is very challenging to formally validate many of the models applied, particularly for contaminant intake to wildlife. There are some aspects of the modelling that rely mainly on measured concentrations in field media (macrophytes, invertebrates, fish) whereas others rely on modelled concentrations using extrapolation from sediment and/or water concentrations. To address the reviewer comment, we believe that the best approach is to discuss, in the uncertainty analysis, the degree to which the model predictions are supported by other lines of evidence. For example, where PCB concentrations are available in fish tissues, it is useful to compare the measured concentrations with those that would be predicted from trophic transfer modelling based on sediment concentrations.

DFO-2014-017

[Chapter V – Options Analysis] • The report states "It is likely that elevated contaminant concentrations in KIH sediments are responsible for the observed brown bullhead abnormalities, although the cause of the DELTs cannot be determined conclusively", however then the next sentence states that "SeQOs for the KIH were not based on deformities in brown bullhead and therefore the definitive cause for observed deformities does not need to be known" (page II-11, paragraph 2). The second statement is incorrect as the fish deformities maybe the resultant of impacts from contamination that is on federal property or originated from federal activity in KIH. This comment requires revision as it pertains directly to fish health in KIH.

- Response Categories 2 and 3
- Response DFO-2014-017 – We generally agree with the Expert Support comment. Although conclusive determination of the cause may not be possible, even with additional study, the development of a risk management strategy does not require determinations to be 100% conclusive. The RMC-ESG assignment of deformities to "elevated contaminant concentrations" is not sufficiently specific to be of value for risk management. If contaminant distributions were highly similar among the main contaminant groups (i.e., PAHs, PCBs, mercury, inorganics), the requirement to determine causation would be lower, as management for one substance would simultaneously address others. However, in the KIH, there are substantial areas for which the contaminant "fingerprint" is dissimilar to the areas prioritized by RMC-ESG in Chapter V; for example, areas in the southwest corner of KIH contain PAHs but lower concentrations of inorganics. Rather than exclude fish deformities in the SeQO evaluation, we believe that the existing information on causation and sediment benchmark concentrations be incorporated in the weight of evidence for ecological health. Although there are residual uncertainties with this approach, it is preferable to the assumption that management of other risk pathways will coincidentally manage risks to fish. The degree to which we can use existing information on fish deformities versus additional site-specific studies is an item for discussion with Expert Support.

  This item has also been flagged as Category 3 because the approach taken depends on the degree of certainty required of the causation assessment. We agree with RMC-ESG that additional studies (e.g., virology, histopathology, etc.) have limitations for the identification of specific causative agents, so even a commitment to further study would not necessarily provide the desired precision in risk estimates or causation assessment.

DFO-2014-018

[Chapter V – Options Analysis] • Before proceeding with any plans for remediation work, the study would greatly benefit from sediment stability assessment to evaluate and better understand critical shear stress for erosion of various areas of contaminated sediments, as well as modeling and prediction of the expected shear stress from wind and water flow driven currents and vessels.

- Response Category 1b
- Response DFO-2014-018 – We generally agree with the Expert Support comment. We have had some discussions with the site custodians on this topic, particularly as they relate to the long-term effectiveness of localized dredging where recontamination could occur. At this stage, we believe that it is appropriate to conduct the risk refinement to identify management areas that are a priority for risk reduction. Once complete, the information would assist in determining the types and locations of sediment stability studies. We agree that development of any detailed remediation plans would require consideration of sediment stability.

4.2 Part B. Technical Memorandum – Review of Revised RMC Reporting on Kingston Inner Harbour Sediments prepared by Golder Associates (March 31, 2014)

DFO-2014-019

[ES-iii (Site Definition)] • The Golder technical memo mentions "there are other risk pathways for which consideration of Anglin Bay remains important". It would helpful to list the specific pathways.

- Response Category 1b.
- Response DFO-2014-019 – In the risk refinement, we will clarify the risk pathways that are drivers for each management unit. The comment made for Anglin Bay was made primarily in reference to surface PAH contamination, which influences the assessments of benthic invertebrates, fish deformities, and possibly human health.

DFO-2014-020

[ES-iii (Ecological Risk Assessment)] • Golder states "… some aspects of the ecological risk assessment (especially for wildlife) still rely on screening level approaches for effects"… and "… it limits the degree to which the results can be reliably used for making remedial decisions given the associated uncertainty and conservatism." Does this mean that these aspects require more detailed assessment or would an acknowledgement of the associated risks be sufficient during decision making?

- Response Category 2.
- Response DFO-2014-020 – Golder has provided alternative TRV derivations for chromium and PCBs, and these TRVs have been incorporated to some degree in Chapter IV. What is lacking in the RMC-ESG reporting is the meaningful consideration of these respective TRVs in Chapter V, where they are discounted entirely, giving preference to the Eco-SSLs from USEPA for calculation of SeQOs (in spite of the latter specifically cautioning that Eco-SSLs "are not designed to be used as cleanup levels." We disagree with the rationale provided on page IV-5 of Chapter V to discount this information, and believe that acknowledgement of the risks and uncertainties associated with candidate TRVs would greatly improve the wildlife risk assessment.

DFO-2014-021

[ES-iii (Ecological Risk Assessment)] • Golder reports that some statements "…lack balance in terms of recognizing the degree of certainty that was actually achieved." Could the statements be changed to reflect those parts of the risk assessment results that could be referred to with great confidence in order to provide a more truthful recommendation or should the areas of uncertainty receive more attention?

- Response Category 1b
- Response DFO-2014-021 – This can be handled directly in the risk refinement, where the level of certainty in each component will be considered in the weight of evidence evaluation.

DFO-2014-022

[ES-vii (Depth profile)] • Golder states "the ability to effectively implement a long-term remediation program based on dredging alone…" is affected by the continuous sediment mixing and resuspension. Are there any other recommendations for other remediation methods to include in addition to dredging?

- Response Category 2
- Response DFO-2014-022 – See response DFO-2014-018 above. There are implications of sediment mixing and resuspension on multiple remediation methods, including those other than dredging. For example, depending on the location, the effectiveness of monitored natural recovery and dredging with clean backfilling would both be influenced by the lateral movement of sediment in the KIH. Effectiveness of remediation in some areas may also be influenced by bioturbation and mechnaical disturbances that influence the vertical distribution of contaminants. As indicated above, we believe that a better understanding of the risk drivers (locations and contaminants) from the risk refinement will help to focus future studies of sediment stability; this approach is consistent with the COA Framework.

DFO-2014-023

[ES-vii] • Golder reports that there is "…concern that the results of the sediment quality triad assessment are summarized in a very broad manner, rather than made location- or unit-specific." In terms of using the information for making site management decisions, would it be more helpful to have results include reference to specific locations or be revised to report on each unit?

- Response Category 2
- Response DFO-2014-023 – See response DFO-2014-001 above. We believe that summarizing risk outcomes at the scale of management units is the most useful approach. For most receptors, the information at individual stations is too detailed to develop a management framework, whereas grouping all stations is too broad. By identifying areas with similar patterns of exposure and risk, we can identify priorities for risk management at a scale that is practical and meaningful. Where necessary, risks to mobile receptors (e.g., fish and wildlife) can be aggregated through consideration of results from multiple management units.

DFO-2014-024

[ES-x (Screening of tissue concentrations for fish health)] • Golder States "the ES comments on the observation of fish deformities in the APEC, and notes that fish tissue COPC concentrations fall below published fish toxicity thresholds. The explanation provided is that the potential interactions among the measured concentrations of COPCs may explain this discrepancy. This is a possibility, although it is speculative." Other studies have shown that COPCs can interact in aquatic environments resulting in synergistic ecological effects. The RMC report would benefit by further elaborating and including further literature references regarding their concerns of increased toxicity to fish from combined COPCs in KIH, particularly PAHs and other COPCs. Please see Gauthier et al. (2014) for recent references. RMC should also consider including PAH toxicity in the fish tissue toxicity screening.

This ES comment also applies to RMC Chapter 4.

- Response Category 2
- Response DFO-2014-024 – See response DFO-2014-014 above. We will incorporate information on possible causes of fish deformities in the risk refinement, including evidence for combined COPC responses (including PAHs) and reference to Gauthier et al. (2014). However, we do not believe that including PAH toxicity in the fish tissue toxicity screening will be useful given that these substances are metabolized in fish. The assessment of PAH toxicity can be accomplished, but entails different methods from whole body PAH chemistry, such as analyses of stomach contents for PAHs, measurement of PAH metabolites in bile, biochemical indicators (e.g., CYP1A activity), examination for DNA adducts in liver, histological evaluation, somatic indices, etc.

DFO-2014-025

[ES-xi (Sediment Management Strategy)] • DFO ES highly agrees with the Golder statement that "The elimination of invertebrates and fish at this stage, presumably on the basis of previous stakeholder input, is not justifiable in our opinion. Risks for all receptors should be carried through the Options Analysis prior to making presumptive decisions from stakeholder feedback."

This ES comment also applies to RMC Chapter 5.

- Response Category 1a
- Response DFO-2014-025 – Agree with comment. One of the challenges with Chapter V is that the SeQOs were developed from consideration of only a subset of the risk pathways. The risk refinement will address this issue by reintroducing risk characterization results for invertebrates and fish and will identify areas where risks to multiple receptors and/or contaminants are overlapping.

DFO-2014-026

[ES-xii (Completion)] • DFO ES highly agrees with the Golder Statement "studies have confirmed that historical deposition of coal tar may be a significant source of PAH contamination within Anglin Bay sediments. The site custodians have an obligation under the COA Framework to continue to investigate these issues as appropriate."

- Response Category 1a
- Response DFO-2014-026 – Agree with comment. That said, we believe that there is now adequate coverage of sampling to develop the risk refinement at the scale of management areas. As the project proceeds toward a management plan, some refinement of contaminant distributions (particularly where contaminants have been observed at high concentrations at depth) may be needed. Our risk refinement will emphasize risks at the surface and near-surface (as these influence current risk levels) with the understanding the deeper contamination will need to be considered as part of the remedial options assessment.

DFO-2014-027

[Chapter I, page III-2] • Golder states that the "application/effectiveness of remedial options..." is constrained by a lack of understanding of the sediment transport and dispersion pattern. Please include a summary of needs and or a discussion of future plans to address this gap.

- Response Category 2
- Response DFO-2014-027 – See response DFO-2014-022 and DFO-2014-018 above. Although we agree that better understanding of sediment transport and dispersion patterns will ultimately be required, the risk refinement based on current surface conditions can proceed in the interim and will help frame needs for sediment stability studies.

DFO-2014-028

[Chapter II, page III-30] • As noted by Golder, the sediment chemistry maps in the RMC report do not include data collected by PWGSC on behalf of Transport Canada and Parks Canada (Golder, page 6). The PWGSC data should be included in the RMC maps.

- Response Category 1b
- Response DFO-2014-028 – See response DFO-2014-005 above. Golder has combined the data from RMC-ESG investigations and data collected by PWGSC on behalf of Transport Canada and Parks Canada. These sources will be included in the risk refinement including associated sediment chemistry maps.

DFO-2014-029

[Chapter III (Bioaccumulation and Lower Trophic Evaluation 5.0)] • Golder states that there are areas of the RMC risk assessment falling short of a DQRA. It would be helpful if these areas were individually identified.

- Response Category 1b
- Response DFO-2014-029 – In the risk refinement, we will discuss the uncertainties for each of the major risk pathways, particularly where such affect the degree of conservatism.

DFO-2014-030

[Prerequisites to Remedial Action] • Golder states that “there are many aspects of the risk assessment that remain uncertain.” If possible, a description of these aspects would provide clarity.

- Response Category 1b
- Response DFO-2014-030 – The purpose of the risk refinement deliverable is to provide such clarity. Some of the parameters (and risk calculations) will change based on Expert Support feedback. In other cases, the risk calculations may not change but additional discussion of uncertainty may be appropriate.

DFO-2014-031

Overall, DFO ES agrees with Golders concerns regarding some of the methods used by RMC-ESG in the risk assessment, and the resultant conclusions and proposed management decisions. Differences between the RMC study and Golder’s studies reoccur within the memo, including several instances where Golder indicates RMC understated the linkages between PAH toxicity in benthic invertebrates and fish, and that the RMC report focus on the Parks Canada portion of the site, rather than a complete assessment of both federal properties in KIH. DFO ES also agrees there still appears to be a lot of uncertainty with estimated levels of ecological risk and further work is needed to characterize and manage contamination in Kingston Inner Harbour to better estimate ecological risks. Overall, the report contains valuable data and information. Ongoing work in KIH would greatly benefit from a collaborative approach between Parks Canada and Transport Canada to better address data gaps, avoid repetition of effort, and obtain a more comprehensive understanding of the overall contamination characteristics and associated remedial options for both federal properties in KIH.

- Response Category 1b
- Response DFO-2014-031 – We are pleased that Parks Canada and Transport Canada have collaborated in the ongoing risk refinement. A key goal of the deliverable will be to reconcile the valuable data and information from multiple studies, some of which were conducted in parallel. It would have been difficult for RMC-ESG to incorporate all the available data when investigations were ongoing.

5.0 ENVIRONMENT CANADA – FCSAP EXPERT SUPPORT PEER REVIEW COMMENTS

5.1 Part A. Application of the Canada-Ontario Decision-Making Framework for Contaminated Sediments in the Kingston Inner Harbour prepared by the Environmental Sciences Group Royal Military College (February 2014)

EC-2014-001

[General Comments] • The Area of Potential Environmental Concern (APEC) is not clearly defined. A site map identifying the site's boundaries is not included in this report. It is unclear whether the APEC referred to in this report encompasses all/part of the Orchard Street Marsh, the Parks Canada and Transport Canada waterlots entirely, or portions of each. Given that risks are assessed and remediation measures are recommended in this report, a clear picture of the area under investigation is critical.

- Response Category 1b
- Response EC-2014-001 – See response DFO-2014-001 above. The site boundaries and subunits (management zones) within the site will be clearly presented in the risk refinement deliverable. We will also strive for clear and consistent terminology in the discussion of geographical areas.

EC-2014-002

[General Comments] • The "Cataraqui River Project Trackdown" study as referenced throughout the report (Benoit and Burniston, 2010) involves a follow-up study on dredging activities in 2004-2005 near the Emma Martin Park to address PCB contamination. The outcome of the study and/or changes of the harbour from this activity, as well as any other remediation activities that have occurred at the site should be addressed in this report.

It is imperative that data used to characterize the contamination in the harbour be representative of current conditions. Data collected prior to dredging or remediation activities should not be used.

- Response Category 1b
- Response EC-2014-002 – See response DFO-2014-005 above. The surface sediment data will be screened to exclude non-representative data.

EC-2014-003

[Executive Summary] • The Cataraqui River Stakeholder Group (CRSG) is described on page iii and lists Environment Canada as a member and key stakeholder. We would like to clarify that the Environment Canada FCSAP Expert Support team is not a key stakeholder nor is it a member of the CRSG. Our involvement is to support and provide technical advice to federal custodians under the FCSAP framework; in this case Parks Canada and Transport Canada.

- Response Category 4
- Response EC-2014-003 – See response DFO-2014-002 above.

EC-2014-004

[Executive Summary] • Page iv states that "the five chapters in this report summarize everything that is known about the Harbour". This is a misleading and inaccurate statement as there are other studies and additional knowledge of the harbour that is not included in this report. This statement should be revised.

- Response Category 4
- Response EC-2014-004 – See response DFO-2014-003, above. We agree with the comment, but will address the underlying issue in the risk refinement deliverable, rather than attempt to modify the RMC-ESG documents.

EC-2014-005

[Executive Summary] • The Next Steps outlined on page xii indicate that stakeholders have identified project aims to guide the assessment and sediment decision-making process. It is important to note that the harbour is on federal land and must also follow the federal framework for contaminated sites.

- Response Category 1b
- Response EC-2014-005 – We agree with the comment. Several parts of the RMC-ESG reporting package indicate that the Cataraqui River Stakeholder Group (CRSG) considered as a decision-making body (i.e., decider of risk pathways and relative importance of various receptor groups). We consider the CRSG engagement as an important consultative process but also one that cannot be used to deviate from the federal framework for contaminated sites. We intend to follow the COA Sediment Assessment Framework as the primary process for evaluating risks under FCSAP; this means that risk pathways to benthic invertebrates and fish, for example, must be carried through the risk characterization phase.

EC-2014-006

[Chapter I – Literature Review] • Similarly to comments for the Executive Summary, Environment Canada FCSAP Expert Support team is not a key stakeholder nor is it a member of the Cataraqui River Stakeholder Group as mentioned on page I-1.

- Response Category 4
- Response EC-2014-006 – See responses to EC-2014-003 and DFO-2014-002 above. We will maintain a distinction between technical advice/recommendations from Expert Support and consultation feedback from CRSG stakeholders.

EC-2014-007

[Chapter II – Spatial Distribution of Contaminants in Sediments] • Sediment data between 1991 and 2008 have been used to generate sediment maps of the contaminated area in the Kingston Inner Harbour as indicated on page II-2 and Table II-1. Given that sediments in this shallow harbour are subject to movement, resuspension, and disturbance, and ongoing sources of contamination have since been mitigated, data from the 1990's (over 20 years old) may be out-dated and should be assessed. Availability and use of more recent data from newer studies should also be explored.

- Response Category 1b
- Response EC-2014-007 – See response DFO-2014-005 above. The comment is nearly identical to comments raised by DFO.

EC-2014-008

[Chapter II – Spatial Distribution of Contaminants in Sediments] • As indicated above, the Area of Potential Environmental Concern (APEC) is not clearly defined. A site map identifying the site's boundaries is not included in this report. It is unclear whether the APEC referred to in this report encompasses all/part of the Orchard Street Marsh, the Parks Canada and Transport Canada waterlots entirely, or portions of each. Given that risks are assessed and remediation measures are recommended in this report, a clear picture of the area under investigation is critical.

- Response Category 1b
- Response EC-2014-008 – See responses EC-2014-001 and DFO-2014-001 above.

EC-2014-009

[Chapter III – Ecological Effects] • Results of the sediment investigation studies in this chapter are summarized as showing 'consistent' evidence of ecological effects (e.g. page ii in executive summary); however this is not consistent with the results which show mixed or no evidence of effects. For example, results from the benthic community study were not conclusive. Furthermore, the results were summarized (page V-2) as having significant differences from reference stations explained by variables related to sediment Cr concentrations. The definitive conclusion reached in this summary is extremely unclear.

- Response Category 1b
- Response EC-2014-009 – We agree with the comment. In our opinion, the confusion arises from an attempt to distill a complex sediment quality assessment into a single conclusion for the entire site. Our specification of management zones, lines of evidence approach, and uncertainty assessment will help consolidate information while also acknowledging important spatial differences in risk characterization outcomes.

EC-2014-010

[Chapter III – Ecological Effects] • The final conclusions reached in this chapter indicate "management actions are needed" (page VI-1) pointing to either scenario 15 or 16 of the COA decision matrix. However, as noted above, it is unclear how this final conclusion was reached given the mixed results from the benthic studies. Other scenarios within this decision matrix may also be considered appropriate based on the results such as scenario 10, which require further investigation in determining reasons for sediment toxicity. Is there a reason why such scenarios were not explored or deemed appropriate?

- Response Category 4
- Response EC-2014-010 – We agree with the comment. However, the COA decision matrix results will change, partly due to use of management zones and partly due to consideration of lines of evidence not included in Chapter III.

EC-2014-011

[Chapter IV – Ecological Risk Assessment] • Page III-2 states that "spatial coverage for the KIH ecological risk assessment is larger than the area used for the human health risk assessment". An accompanying map should be included to clarify the boundaries of each risk assessment.

- Response Category 1b
- Response EC-2014-011 – See responses EC-2014-001 and DFO-2014-001 above. Note that zones for the human health assessment (and wildlife) will be larger than those for lower trophic level assessment, in recognition of the larger home ranges and mobility of receptors.

EC-2014-012

[Receptors of Concern] • It is unclear why lower trophic levels such as macrophytes and benthic invertebrates were not included in the risk assessment. Toxicological data is available to assess the risk of these organisms. Thorough rationale should be provided as to why they were excluded.

- Response Category 1a
- Response EC-2014-012 – See response DFO-2014-010 above.

EC-2014-013

[Receptors of Concern] • The muskrat and red wing black-bird should be considered in the risk assessment. The rationale for their exclusion being that they only use marsh habitat (page III-2 and Table IV-23) seems to contradict the statement earlier in the paragraph that "it is not advisable to consider the contaminated portion of the KIH in isolation from the Orchard Street Marsh". In addition, both the red-wing black bird and muskrat are highly mobile and can potentially travel and ingest food outside the marsh. To address uncertainty as to whether these two receptors link to the harbour, and whether they are relevant receptors to include in the risk assessment, their home ranges and food sources can be better defined to verify whether they remain within the marsh or extend into the harbour and into the Parks Canada portion of the marsh.

- Response Category 2
- Response EC-2014-013 – We agree that the sentence in question is somewhat contradictory. It is possible that RMC-ESG was referring to a broader plan for risk management that includes not only the sediments part of the federal water lots but also terrestrial risks on adjacent lands. To address the reviewer comment, we will explore differences in home ranges, dietary composition, and other biological characteristics among candidate wildlife species. This information will be incorporated in the uncertainty assessment, rather than in the calculation of hazard quotients, to evaluate whether other species may be equally or more susceptible to risks from sediment exposure, particularly in the creek adjacent to Orchard Street marsh.

EC-2014-014

[Receptors of Concern] • There were no species at risk evaluated for risk. It should be verified that no species at risk inhabit or frequent the site.

- Response Category 1b
- Response EC-2014-014 – As noted elsewhere in the FCSAP comments, there are listed species at the Site. We will evaluate whether risks to these species are likely to be greater, equal to, or less than those identified for the receptors of concern formally evaluated by RMC-ESG. Because risks to wildlife were evaluated at the level of individual organism, rather than population or community level, it is possible to make such comparisons.

EC-2014-015

[Receptors of Concern] • There is no reason why protection of amphibians and reptiles at contaminated sites is of lesser importance than protection of other species such as mammals, birds, fish and invertebrates which are routinely included in ecological risk assessments. If amphibians and/or reptiles are present at the site, they should be considered potentially sensitive receptors requiring further consideration in the risk assessment; at the very least, additional rationale (other than a lack of toxicological information) should be provided as to why these potential receptors have not been further considered. Note that numerous turtles had been spotted during a site visit to Kingston Inner Harbour with expert support staff on June 4th, 2013 indicating the presence of reptiles.

- Response Category 2
- Response EC-2014-015 – We agree we both perspectives, including the limitations of toxicological information for several of the receptor/contaminant pathways, but also the need to evaluate herptiles using what information is available. Although limited relative to information on invertebrate toxicity, there are some data (such as sediment and tissue benchmarks for PCBs) from other sites that could be used to reduce uncertainty in the assessment..

EC-2014-016

[Exposure Pathways] • The exclusion of fish exposure pathways is unclear. Why were these pathways not explored?

- Response Category 1b
- Response EC-2014-016 – Fish exposure pathways were considered in the RMC-ESG deliverables, including evaluation of tissue chemistry relative to benchmarks, plus discussion of bottom fish deformities. However, the Chapter 5 material did not incorporate this information in the development of SeQOs; we intend to address this in the risk refinement deliverable.

EC-2014-017

[Exposure Pathways] • It is difficult to determine if the fish tissue residue evaluation was appropriately conducted. Were the appropriate TRVs used for the tissue analyzed? Various TRVs isolate specific tissue (ex: liver, ovaries, etc.). It was also noted that TRVs used for the fish tissue residue study were not appropriate for brown bullhead fish or species with similar behaviour (page III-37). Given the uncertainties with this approach, risk assessed through exposure pathways may need to be reconsidered.

- Response Category 2
- Response EC-2014-017 – Fish tissue benchmarks for protection of fish populations are typically derived based on whole-body measurements in fish, except where the mechanism of action indicates an alternate approach is warranted (e.g., PAH accumulations in bile). We disagree that TRVs used for the fish tissue residue study are not appropriate for brown bullhead fish; although there is uncertainty in interspecies extrapolation in ecological risk assessments, it is common to use TRVs developed for a species or group of fish to other types of fish in similar habitats. This issue will be discussed in the uncertainty assessment.

EC-2014-018

[Exposure Pathways] • Morphological abnormalities in brown bullheads were considered a measurement endpoint of fish health (page III-16). Causes of these lesions were speculated to be a cause of the interaction of chemical mixtures within the sediments (page III-37). Provided that the fish tissue residue study concludes that the fish community in the APEC is not at risk, how is the information for the fish abnormalities being utilized? Are further assessments (such as with fish exposure pathways) being considered? Are any of the remediation options taking into account the fish abnormalities found in the APEC?

- Response Category 1b
- Response EC-2014-018 – The fish abnormality information has not yet been considered in the remediation options assessment. The RMC-ESG options assessment makes the assumptions that wildlife and human health risk are to be considered the drivers for management (based to CRSG consultation) and that remediation for those pathways will necessarily address risks to bottom fish. We do not believe that this approach is consistent with the COA framework, and therefore will retain characterization of all receptors (including invertebrates and fish) in the risk characterization and weight of evidence stages.

EC-2014-019

[Risk Characterization] • Food ingestion for the mink is highly conservative as it assumes a diet comprised of 100% fish as opposed to 30% as indicated in FCSAP guidance (Azimuth, 2012).

- Response Category 1b
- Response EC-2014-019 – This is one of several parameters that can be evaluated in the uncertainty assessment. The contribution of fish to mink diet is variable among sites, as they are opportunistic predators. We will evaluate the conservatism of this parameter in the context of the habitat and food resources present at the Site, and consider the conservatism and uncertainty when discussing the hazard quotients derived.

EC-2014-020

[Risk Characterization] • Hazard quotients for the mallard duck were calculated using a 100% benthic invertebrate diet, the most conservative calculation, and a 50% benthic invertebrate 50% plant diet, which is more realistic. It is surprising that the hazard quotient increased from 1.6 to 3.8 respectively. Is there a possible explanation for this?

- Response Category 1b
- Response EC-2014-020 – We will evaluate the concentrations predicted in invertebrates and plant diet, including whether the data are based on measurements or predictive models.

EC-2014-021

[Risk Characterization] • The risk assessment includes a large proportion of modelling, which in turn is the basis for the remediation proposed in Chapter V. Much of this modelling does not include validation or calibration. For example the food web model used to determine concentrations in sediment resulting in target tissue levels of PCBs in fish. While it is recognized that validation and calibration is not possible for all aspects, an overall summary would be beneficial.

- Response Category 1b
- Response EC-2014-021 – See response DFO-2014-016, above.

EC-2014-022

[Chapter V – Options Analysis] • As noted in the Golder memo, it appears that data from Anglin Bay (coal tar found at depths between 30 and 100 cm) as well as relatively high concentrations of PAHs has not been incorporated into the RMC report. Since the report recommends an option that factors concentration reductions into achieving acceptable hazard quotients, such data will need to be incorporated into a revised risk assessment and remediation plan.

- Response Category 2
- Response EC-2014-022 – We agree that surface (or near-surface) sediment chemistry data should be incorporated in a revised risk assessment. The contamination at depth should ultimately be considered in the remediation plan; however, the risk refinement deliverable will focus on near-surface contamination, as the latter influences current risk levels. The importance of subsurface contamination will depend on several other factors, including sediment stability and surface management alternatives, which have not yet been evaluated in detail.

EC-2014-023

[Chapter V – Options Analysis] • On page V-2, the report states that “although mink are confirmed to be present in the harbour, there is limited suitable habitat and it may not be appropriate to determine sediment management scenarios based on potential risks to mink.” This comment is confusing; the mink was determined a receptor of concern exposed to unacceptable levels of risk in Chapter IV. This rationale requires further explanation on how it is consistent with the analysis of the risk assessment.

- Response Category 1b
- Response EC-2014-023 – The text appears to be equivocation resulting from uncertainty regarding the ecological importance of the mink risk assessment results. In the risk refinement, we will reconsider some of the parameter choices (per other FCSAP Expert Support comments), and also provide an uncertainty assessment, to provide an indication of the overall risk to wildlife.

EC-2014-024

[Chapter V – Options Analysis] • Also on page V-2, it states that ‘Final decisions on management scenarios will be determined through stakeholder consultation’. As noted in earlier comments, this site is on federal land and must also follow the federal framework for contaminated sites.

- Response Category 4
- Response EC-2014-024 – We agree with the FCSAP comment.

EC-2014-025

[Causation] • On page II-11, the report mentions that the cause of deformities for the brown bullheads does not need to be known because the SeQOs were not based on them. This statement is incorrect if historical contamination on federal real property, or originating from federal activity at the site, is the cause of these deformities. This comment requires clarification and/or elaboration as it pertains directly to the importance of fish health in the harbour.

- Response Category 4
- Response EC-2014-025 – We agree with the FCSAP comment. We will be retaining risks to fish, including bottom fish deformity assessment, in the risk refinement. The degree to which causation is known or unknown does have relevance because it influences the degree of certainty that the overall management plan will be effective.

EC-2014-026

[Causation] • The report determines that PAHs are unlikely to be the cause of the tumours in KIH fish since sedimentary PAH concentrations were generally low (page III-35). However, in Baumann (2013), the author states that sediment concentrations of 10 ppm total PAH indicates a marker above which significantly elevated tumour rates are likely. Since mean PAHs concentrations in the APEC are 199 ppm when taking into account samples in Anglin Bay and 10 ppm when depth samples from Anglin Bay are removed, PAH’s may be an important contributor to fish tumours in the APEC.

- Response Category 1b

- Response EC-2014-026 – We agree with the FCSAP comment, and disagree with the dismissal of PAH risk based on either the exposure assessment or the effects assessment. Based on our evaluation, PAHs are likely to be the leading cause of fish deformities, although contributions or interactions of PCBs, metals, or other substances cannot be conclusively ruled out. We will retain assessment of PAHs in the risk refinement, both for invertebrate health and fish health, and will discuss the uncertainties in the assessment.

EC-2014-027

[Sediment Management and Recommendations] • While the approach of removing polygons to bring the area average (95thUCL) down to one that results in acceptable hazard quotients works in theory and is a concept that is applied to contaminated sites, this approach raises a few concerns:

- Since the contaminated matrix is sediment which is mobile under certain conditions, redistribution of contaminants will occur throughout the harbour. It is certainly possible to achieve an acceptable average by removing enough hotspots, however, redistribution can also occur.

- Since the averaging is based on chemical concentration and not mass, there exists the possibility for areas that are left unremediated to contribute contamination to areas that were remediated, acting as potential sources of recontamination. In areas where concentrations increase with depth, the average contamination can begin to increase from its intended level. A possible solution to this problem could be to remove/dredge enough polygons to incorporate a safety buffer.

- Response Category 1b
- Response EC-2014-027 – We agree with these FCSAP comments, which overlap with other comments discussed above. We will address these issues in part through development of sediment management areas, although future consideration of sediment stability will also inform the remediation plan.

EC-2014-028

[Sediment Management and Recommendations] • There is concern with the representation of risk at the site. It appears that the entire site is used in calculating exposure doses. This is a large area in which some of the receptors would not utilize the entire site. Therefore, the reduction of the overall average through removing hotspot may still leave receptors having specialized or small home ranges with unacceptable concentrations available to them. It would be beneficial to determine the home range of such receptors and tailor relevant hotspot removal for their particular home ranges.

- Response Category 1b
- Response EC-2014-028 – We agree with these FCSAP comments, which overlap with other comments discussed above and below. For some of the receptors, averaging areas will be redefined to reflect the foraging areas or plausible exposure scenarios.

EC-2014-029

[Sediment Management and Recommendations] • A sediment stability assessment to evaluate critical shear stress for erosion of various areas of contamination as well as modeling and prediction of the expected shear stress from wind driven currents and vessels would be appropriate for this site. An understanding of the stability of unremediated sediment would be important prior to proceeding with a final plan.

- Response Category 4
- Response EC-2014-029 – Agree with comment; however, these studies can be deferred pending the outcome of the risk refinement, which will help to identify priorities (i.e., contaminants, locations, and receptors driving risk).

EC-2014-030

[Sediment Management and Recommendations] • While dredging is outlined as the preferred remedial option, many remediation projects utilize more than one option (mixed remedies) to achieve their goals. For example, some options may be better for certain areas of the site. Often in the sediment management option evaluations, lab or field work is identified in order to support or eliminate some of the options where uncertainty exists. An example would be the ability for the sediment to support a cap in certain areas. Testing would have to be conducted otherwise these critical aspects will remain unknown and creating difficulties with decisions moving forward.

- Response Category 4
- Response EC-2014-030 – Agree with comment; however, these studies can be deferred pending the outcome of the risk refinement. The potential role of enhanced natural recovery, backfilling, engineered covers, and other options in addition to simple excavation, will become more clear following the completion of the risk refinement.

5.2 Part B. Technical Memorandum – Review of Revised RMC Reporting on Kingston Inner Harbour Sediments prepared by Golder Associates (March 31, 2014)

EC-2014-031

Overall, the comments submitted by Golder raised important points for all chapters in the RMC report and provided an additional and valuable expert perspective.

- Response Category 1a
- Response EC-2014-031 – Thank you; no response required.

EC-2014-032

Please note that comments on the human health risk assessment were not reviewed by Environment Canada. Please also note that Environment Canada has not reviewed much of the Kingston Inner Harbour studies carried out by Golder for Transport Canada and cannot comment on the results from these studies.

- Response Category 1b
- Response EC-2014-032 – Comment acknowledged; one of the objectives of the risk refinement is to integrate all relevant information including supplemental studies conducted for Parks Canada and Transport Canada.

EC-2014-033

It did not seem evident in the RMC report that sediment chemistry maps had been updated with data collected by PWGSC on behalf of Transport Canada and Parks Canada as indicated by Golder on page 5 section 3 of the memo. For reference, Table II-1 on page III-1 in Chapter II of the RMC report lists all studies used for mapping. The inclusion or exclusion of PWGSC data in the RMC maps should be verified.

- Response Category 1b
- Response EC-2014-033 – The risk refinement deliverable will include these data, while also addressing the issue of temporal relevance identified above.

EC-2014-034

Differences in opinions and focus between the RMC report and Golder's studies reoccur within the memo. This is particularly evident with linkages to PAH causality of toxic effects to benthic invertebrates as well as to brown bullheads that were expressed as being understated by RMC in the Golder memo (page 3, page 10, page 11). Also, the study domain of the RMC report, as noted by Golder had a tendency to focus on the Parks Canada portion of the site and not provide a complete assessment of both federal properties (section 4.0, page 6). Such examples indicate that a comprehensive summary of the harbour for both federal properties has not successfully been achieved in the RMC report.

Moving forward, an appropriate step would be for Parks Canada and Transport Canada can to work collaboratively to address data gaps and achieve a comprehensive understanding of the harbour for both federal properties as well as avoid duplication of effort. Once data gaps are filled they can be incorporated into reports used to make a final decision (such as in an expanded remedial option analysis that brings all data together as well as include input from vested parties).

- Response Category 1b
- Response EC-2014-034 – These concerns are a major reason why the risk refinement deliverable is being prepared, in contemplation of a future collaborative remedial options analysis.

6.0 HEALTH CANADA – FCSAP EXPERT SUPPORT PEER REVIEW COMMENTS

6.1 Part A. Application of the Canada-Ontario Decision-Making Framework for Contaminated Sediments in the Kingston Inner Harbour prepared by the Environmental Sciences Group Royal Military College (February 2014)

HC-2014-001

Our understanding is that, with the exception of perhaps some early studies, this report has generally not been prepared on behalf of, or funded by, either of the Custodial departments (Parks Canada (PC) and Transport Canada (TC)) that own the Kingston Inner Harbour (KIH) water lots that comprise the main study area. Health Canada (HC) in its FCSAP Expert Support (ES) role continues to support these custodial departments by providing human health related comments on ongoing KIH reporting, at their request.

It is noted that, although ESG has to a limited degree made an effort to incorporate a selection of the more recent work completed by others on behalf of the custodial departments, the ESG report uses wording that implies that there is a general consensus that the ESG report is the definitive study regarding the KIH, that its methodology and conclusions have been adopted and that the next steps in KIH sediment management are evident as a result. Concurrent KIH studies completed on behalf of TC (Golder, 2011, 2013, 2104, etc.) indicate that this is not accurate. Furthermore, PC and TC have indicated that human health and environmental site and risk assessment is ongoing and that support from ES Departments (ESDs, i.e. EC, HC and DFO) will continue to be sought as the Custodians manage their respective water lots.

- Response Category 1b.
- Response HC-2014-001 – Agree with comments; such concerns have resulted in the risk refinement report being conducted.

HC-2014-002

We have focused our review of the ESG report on the parts of the report relating to our mandated areas (i.e. potential risk to human health) and other ESDs have done the same with regards to their mandates. Based on a review of the human health related sections of the above noted documents, HC recommends that the results of the human health risk assessment (HHRA - Chapter IV of the ESG Report) and the management options analysis (Chapter V of the ESG report) be considered within the context of the comments provided herein, as some comments are significant in nature and thus may impact the interpretation of the HHRA and any decisions stemming from it.

- Response Category 1b.
- Response HC-2014-002 – Following review of the full FCSAP Expert Support comment package, we agree that decisions may be significantly affected. At the same time, we do not have the scope to repeat or revise all aspects of the RMC-ESG risk assessment, nor do we believe that such is warranted. Instead, we recommend that select key assumptions/parameters be revaluated quantitatively, focussing on those decisions that most significantly influence risk outcomes, and we are soliciting additional Expert Support input on some of these topics. The overall objective is to evaluate the consequences for overall risk characterization; in some cases this will entail revision of HQ estimates whereas in other cases a narrative discussion in the uncertainty assessment will suffice.

HC-2014-003

[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • With the exception of antimony, the suite of metals included in the list of COPCs for the lower Kingston Inner Harbour (KIH) appears to be limited to those with Canadian Council of the Ministers of the Environment (CCME) sediment quality guidelines. The report includes raw data and a summary of sediment data only for the COPCs (i.e., maximum, minimum, mean and 95% upper confidence limit of the mean {UCLM}) and it is not clear whether other metals were analyzed or considered in the COPC screening process. It appears, based on the summary of previous investigations in the KIH provided in Chapter II, that a full suite of metals has been analyzed for at least a subset of samples from the lower KIH. We also note that data for VOCs in sediment are reported for one sample from the KIH in a previous version of Chapter II, including relatively low but measureable concentrations of BTEX, isopropylbenzene and trimethylbenzene. Summary data for all substances measured in sediments in KIH should have been included in the report along with the screening values used and the corresponding data from the reference site, where applicable. Substances with no CCME screening value should be screened against appropriate screening values from other jurisdictions and/or data from reference sites, where available. In cases where no screening values are available, the substances should be carried forward as a COPC unless it can be clearly shown that concentrations in sediments in the lower KIH are not significantly different than those in the reference area and that there are no hot spots or areas with locally elevated sediment concentrations. Transport Canada and Parks Canada may wish to evaluate the raw sediment data from their respective properties to determine whether any other substances should have been retained in the risk assessment.

- Response Category 1b.
- Response HC-2014-003 – Additional screening information will be provided in the risk refinement deliverable. Where CCME guidelines are not available, we will consider comparisons to sediment guidelines from other jurisdictions, soil guidelines if necessary, and will consider whether substances associated with relevant industrial activities have been captured in the screening (e.g., Health Canada Part I *Table A2 Contaminants Commonly Associated with Various Governmental and Industrial Activities*).

HC-2014-004

[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • The portion of the KIH north of Belle Island (i.e., the upper KIH) has been selected as the reference area. The report notes that this portion of the KIH has been minimally impacted by past industrial activities. The former Belle Park landfill forms part of the southern border of the upper KIH and it is not clear whether the former landfill has impacted sediments in this area as the former landfill is listed as a source of COPCs to the lower KIH. Also, it is not clear whether there were any other potential historical sources of contamination to the upper KIH. We note that the 95% UCLM for reference data appears to be higher than the Ontario sediment screening values and Ontario background concentrations for most metals and for PCBs. It appears that all sediment COPCs listed in Table II-2 and Tables IV-3JV-5, IV-7 were retained even if the data from the KIH was not considered significantly greater than the data from the reference area. Therefore, any issues related to the selection of sediment reference sites would not be expected to have any implications for overall findings of the human health risk assessment (HHRA) as they pertain to the COPCs that were presented in Chapter IV. If substances with no sediment screening values were compared with data from the reference area, the data from the reference area may need to be re-evaluated to confirm that there are no areas of localized contamination (e.g., adjacent to the former Belle Park landfill) that would bias the reference data high.

- Response Category 1b.

- Response HC-2014-004 – Although there are a few areas north of Belle Island that exhibit sediment concentrations higher than in other reference areas, the vast majority of stations have exhibited concentrations of COPCs that are much lower than along the western half of the southern KIH. Furthermore, sampling of reference stations for effects data (e.g., benthic community assessment, toxicity testing) and for bioaccumulation assessment has emphasized the areas of the upper KIH that have been least influenced by urban contamination. As noted above, the retention of most substances (irrespective of the statistical comparisons to reference) means that risk characterization outcomes are not sensitive to the details of this screening. To address this concern, calculations of averages in the risk refinement will exclude data points that may reflect areas of localized contamination that would bias the reference data high.

HC-2014-005

[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • It appears that COPC concentrations in sediments for the entire lower KIH (below Belle Island) were used to compare the impacted areas to the reference area. We do not agree with this approach. For most COPCs, the impacted area in the lower KIH is localized primarily to the western portion of the lower harbour, while the eastern portion of the lower harbour appears to be relatively unaffected by the sources along the western shore. For each COPC, only data from the impacted sediments should be used to compare impacted areas with the reference area. For example, based on information provided on Map 11-10, arsenic concentrations in sediments exceeding the ISQG appear to be limited to the western portion of the shoreline, extending between 200 m and 400 m offshore (an area that may occupy only approximately one third of the lower KIH). Arsenic concentrations in sediments exceeding the PEL are limited to a much smaller area along the central portion of the shoreline of the lower KIH. Map 11-10 clearly shows a distinct area of sediments impacted by arsenic and data from areas that are not impacted should not be included in the comparison between the impacted portion of the lower KIH with data from the reference area.

- Response Category 2 – Requires liaison with Expert Support.
- Response HC-2014-005 – We agree with the comment, and have proposed to develop management areas that integrate sediment bed zones with similar contamination profiles. We would like to discuss our approach with Expert Support to confirm that the divisions of the impacted area are of an appropriate scale.

HC-2014-006

[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • It is not clear where fish tissue reference data were collected and sufficient rationale was not provided to support the selection of the reference location. In particular, it was not clear whether the home range of fish from the reference area could include the KIH or whether there are potential sources of COPCs in the reference area. The Ontario Ministry of Environment (OMOE) Sport Fish Contaminant Monitoring Program could be contacted for further guidance. It may also be useful to determine whether OMOE considered metals other than mercury and chromium when they established the fish consumption advisories for the KIH.

- Response Category 1b.
- Response HC-2014-006 – The location of both exposed and reference tissue collections have relevance to the risk refinement, as we will be linking tissue collections to areas of KIH. RMC-ESG has provided sufficient information of the location of fish samples to make these assignments. Additional details will be provided in the risk refinement deliverable.

HC-2014-007

[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • We could not find details regarding the statistical analyses used to compare data from KIH to the reference area. Therefore, we could not check the approach and interpretation.

- Response Category 1a.
- Response HC-2014-007 – The statistical comparisons will be revised based on the division of water lots into management zones, and through exclusion of anomalous reference concentrations, both per previosu comments for Expert Support. Therefore, the details of what was done in the RMC-ESG deliverables will no longer be applicable.

HC-2014-008

[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • Tables in Section B.I of the HHRA include Ontario Ministry of Environment (OMOE) sediment quality standards but not CCME sediment quality guidelines. Given that the KIH is under federal jurisdiction, the CCME sediment quality guidelines should also be considered for screening sediments, unless agreements between Federal and Provincial governments are in place that would warrant the use of OMOE sediment quality standards.

- Response Category 1b.
- Response HC-2014-008 – The work conducted by Golder for Parks Canada and Transport Canada has already considered CCME sediment quality guidelines (where applicable) and has also considered guidelines from other jurisdictions. The risk refinement report will continue with this approach.

HC-2014-009

[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • The tissue screening value of 0.5 mg/kg for mercury cited in Table IV-9 was developed by Health Canada for retail fish and, in some cases, may not be an appropriate value for screening sport fish tissue as consumption patterns for sport fish may differ than those that were assumed for retail fish for the purposes of developing the retail fish screening value. The OMOE consumption guidelines listed in Table IV-9 appear to be from the 2009-2010 Guide to Eating Sport Fish and would likely represent a more appropriate screening value for tissue concentrations in sport fish, provided the assumptions regarding sport fish consumption used to derive the values are reasonably representative of consumption patterns expected at the KIH.

- Response Category 1b.
- Response HC-2014-009 – This information will be considered in the risk refinement.

HC-2014-010

[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • Please note that the FDR/HC guidelines for arsenic and lead in fish protein cited in Table IV-9 apply to powdered fish protein and do not apply directly to fish tissue. According to the Food and Drug Regulation, fish protein "(a) shall be the food prepared by (i) extracting water, fat and other soluble components through the use of isopropyl alcohol from fresh whole edible fish of the order Clupeiformes, families Clupeidae and Osmeridae and the order Gadiformes, family Gadidae, or from trimmings resulting from the filleting of such fish when eviscerated, and (ii) drying and grinding the protein concentrate resulting from the operation described in subparagraph (i); (b) may contain a pH adjusting agent; and (c) shall not contain (i) less than 75 per cent protein, which protein shall be at least equivalent to casein in protein quality, as determined by official method FO-1, Determination of Protein Rating, October 15, 1981." Sufficient rationale is not provided to justify application of these guidelines for screening fish tissue concentrations. We note that lead in fish tissue was not retained for further evaluation as the concentrations in the KIH were not significantly different from those in the reference area. Therefore, use of these screening values would not impact the overall finding for lead (provided that reference samples have not been impacted by the sources in the lower KIH or other point sources). It appears that the FDR/HC guidelines were used to screen out arsenic in fish tissue as the reference data could not be used for screening, although this was not explicitly stated. Arsenic concentrations in all of the reference samples were below the detection limit but the detection limit for the reference samples exceeded the maximum concentration measured in fish tissue from the study area. Further rationale should be provided for screening out arsenic in fish tissue, including justification for the use of the FDR/HC guidelines.

- Response Category 2.
- Response HC-2014-010 – We agree with the comment and propose to reassess the technical basis for screening of arsenic and lead through dietary consumption.

HC-2014-011

[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • Based on correspondence between HC and OMOE between June 24 and 26, 2014 the fish consumption advisories for the KIH are based on PCBs, mercury and chromium. It appears that mercury and chromium have been excluded as a COPC in fish tissue based on a comparison of site data with reference data. At a minimum, it should be acknowledged that OMOE has established fish consumption advisories in the KIH based in part on mercury and chromium in fish tissue.

- Response Category 2.
- Response HC-2014-011 – Agree with comment; the basis for consumption advisories will be discussed in the risk refinement report, and implications for screening of pathways and substances considered.

HC-2014-012

[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • The text states in several locations that there is strong evidence that chromium from sediment is bioaccumulating into aquatic organisms. Also, as noted above, the fish consumption advisory for the KIH is based in part on chromium levels in fish tissue. The maximum and 95% UCLM for chromium in tissue from the study area are more than double those in the reference area. However, chromium in fish tissue from the reference area was found to be not statistically different from that in the study area. Therefore, chromium was not retained as a COPC in fish tissue. Parks Canada and Transport Canada may wish to confirm the validity of the reference samples and the statistical analyses given that Cr is shown to be bioaccumulating. Also, in any future evaluations of health risk associated with consumption of impacted fish in the lower KIH, it should be acknowledged that OMOE has established fish consumption advisories in the KIH based in part on chromium in fish tissue.

- Response Category 2 – Requires liaison with Expert Support.
- Response HC-2014-012 – Agree with comment; the basis for consumption advisories will be discussed in the risk refinement report, and implications for screening of pathways and substances considered.

HC-2014-013

[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • Based on information in the OMOE (2010) report Cataraqui River Project Track-Down: Follow-up Study on Success of Remediation Efforts in the Cataraqui River 2006, it appears that sediments adjacent to Emma Martin Park were dredged in late-2004. However, based on information in Table II-1, it appears that eight of the twelve sediment sampling programs used to map the spatial extent of COPCs were completed prior to 2004. The report does not mention the dredging program off Emma Martin Park and it is not clear whether data that were collected from the dredged area prior to dredging were included in the risk assessment. It is recommended that the database be re-evaluated to confirm that data included in the risk assessment represent post-dredging conditions and that data from sediments that were removed from the KIH were not included.

- Response Category 1b.
- Response HC-2014-013 – See response DFO-2014-005; the risk refinement will exclude data for locations within the dredge footprint that were collected prior to dredging program off Emma Martin Park.

HC-2014-014

[Chapter IV - Defining Exposure Point Concentrations] • Given the substantial amount of sediment data available for the KIH, we agree with using a statistic other than the maximum measured concentration to represent the exposure point concentration. However, we do not agree with the use of 95% UCLM for the entire inner harbour to represent the exposure point concentrations for human receptors or to screen out COPCs. Based on the information provided in Maps II-6 through 11-16, it appears that there are hot spots or localized areas of higher concentrations for each of the COPCs (typically along the western shored) and for most COPCs it appears that at least half of the KIH (typically the east half) has relatively low concentrations (i.e., below the PEL and in some cases below the ISQG). Given the large area represented by the KIH, individuals would not be expected to be exposed to all sediments in the entire harbour equally. Instead, it would be expected that an individual would spend time within a smaller area within the harbour. Different individuals may spend time in different areas of the harbour and, with the exception of boaters, activities would be expected to be , focused at or near the shoreline. Given that the hot spots for most COPCs appear to be localized at and/or near the shoreline on the western side of the KIH, some people may be expected to be exposed to average COPC concentrations that are substantially higher than the" 95% UCLM for the entire harbour. For example, based on the contaminant concentration profiles in Maps II-6 and 11-12, the highest concentrations of antimony and chromium appear to be found primarily in the area south of Cataraqui Park, east of Orchard Street Marsh. This area also has lead concentrations in sediment that are substantially higher than most of the rest of the harbour (see Map II-7). If a receptor were to visit this area, the average sediment concentrations of antimony, chromium and lead to which they would be exposed would be substantially higher than the 95% UCLM for the entire harbour. The human health risk estimates based on the 95% UCLM for the entire harbour should not be considered reliable estimates of potential risks for individual receptors accessing the shoreline at various locations along the western shore of KIH. Health risks associated with exposure to chromium, copper, zinc, DDT, chlordane, naphthalene and pyrene were considered acceptable based on exposure to the 95% UCLM for the entire harbour. However, for receptors who visit areas with localized higher concentrations of COPCs in sediments (e.g., the area adjacent to orchard street marsh and Belle Park and the area between the marinas and Emma Martin Park) potential health risks may be substantially higher than predicted as these receptors would be exposed to an average sediment concentration that is substantially higher than the 95% ULCM for the entire harbour.

- Response Category 2.
- Response HC-2014-014 – Golder agrees with the general point being made, and proposes to address the issue through use of management zones rather than through calculation of the 95% UCLM for the entire contaminated zone. The objective will not be to identify small scale “hotspots” but rather to identify areas that may be expected to integrate exposures differently from other zones. We would like to liaise with Expert Support to confirm that the number of zones identified is appropriate for the assessment of human and wildlife health risks; these pathways will combine exposure over multiple areas, through their own foraging behaviour and through the movements of prey.

HC-2014-015

[Chapter IV - Defining Exposure Point Concentrations] • Special management areas: Section F of the HHRA introduces the concept of special management areas (SMAs), which appear to be areas with localized higher concentrations of a particular COPC. Special management areas appear to be defined only for arsenic, mercury, PCBs and PAHs based on considerations related to human health and for chromium and PCBs based on considerations related to ecological health. The human health risk assessment presents risk estimates for arsenic and mercury within the SMA and for arsenic and mercury outside the SMA. The exposure point concentrations defined for the SMAs may provide a more realistic estimate of the concentrations that people who visit this area may be exposed to (depending on how they were defined relative to the contaminant distribution and relative to the areas that people may frequent) resulting in more realistic risk estimates for these receptors. There appears to be an area of localized elevated mercury concentrations in sediments outside of the SMA in the vicinity of the marinas. The use of the 95% ULCM mercury concentrations in sediments for the remainder of the KIH outside of the SMA to estimate risk for human receptors would not account for this hot spot where people may be exposed to substantially higher concentrations throughout the area. If people are expected to be exposed to COPCs in sediments in areas with locally elevated concentrations, health risks should be evaluated for these areas using an exposure point concentration that is representative of the area where an individual may be exposed.

- Response Category 2.
- Response HC-2014-015 – See response HC-2014-014 above. We were also confused by the concept of special management areas (SMAs) because there was not a clear articulation of why SMAs were developed for some pathways and substances but not for others. As before, we would like to confirm the scale of management areas that best strikes a compromise between the need to average exposures over areas (for realism and relevance to plausible exposure scenarios) and the need to acknowlege larger contiguous areas of sediment that have a different contamination profile than other parts of the harbour.

HC-2014-016

[Chapter IV - Defining Exposure Point Concentrations] • Table IV-22 provides HQ values for arsenic, inorganic mercury and lead that have been adjusted for background exposure, such that a threshold of 1 would be more appropriate than a threshold of 0.2 for defining potentially unacceptable risk. The HQ values reported for the area outside the SMA would only be an appropriate representation of human exposure outside the SMA if the sediment concentrations outside the SMA are relatively uniform throughout the entire KIH and there are no significant hot spots or areas where COPCs are locally elevated. As noted above, there appears to be at least one significant hot spot of mercury in sediments outside of the SMA in the vicinity of the marinas. Therefore, the HQ values reported for mercury in sediments outside the SMA (which are based on a 95% UCLM for the entire harbour outside the SMA) may not accurately reflect potential risks for people who would be exposed to mercury in sediments in the vicinity of the marinas. Likewise, the lead HQ for the entire KIH would not be representative of human exposure in areas with locally elevated concentrations along the shoreline.

- Response Category 1b.
- Response HC-2014-016 – This concern should be addressed through the specification of new management areas, and/or through adjustment of the screening HQ to 0.2 for As, Hg and Pb.

HC-2014-017

[Chapter IV - Defining Exposure Point Concentrations] • Two samples from the outlet of the Orchard Marsh at depths of 17.5 cm and 52.5 cm with antimony concentrations substantially higher than most of the rest of the KIH were removed from the data set and human health risks were re-calculated based on the 95% UCLM of the remainder of the data set for the KIH. No rationale was provided for removing these two samples. If it is presumed that people would not be exposed to sediment at these depths and if surficial sediments in these areas have been characterized, it may be reasonable to remove these samples from the data set. However, as noted previously, the 95% UCLM for the entire KIH may underestimate risks to people who would access the shoreline in the vicinity of Orchard Street Marsh, Cataraqui Park and the former lead smelter as there appears to still be sediments with elevated antimony concentrations well above the CCME soil standard in this area even when the two samples at depth are excluded.

- Response Category 1b.
- Response HC-2014-017 – Samples collected at depth will be removed from the database used to assess present-day risks. However, contamination at depth will be considered in the future pending the outcome of the risk refinement. The risk refinement will include rationale for screening on sediment chemistry data in the vertical dimension.

HC-2014-018

[Chapter IV - Defining Exposure Point Concentrations] • Pg II-6 (Chapter IV): Samples with elevated PAH concentrations at depths ranging from 31 to 123 cm collected from the Anglin Bay area with "extremely high concentrations of PAHs" (total PAHs 18-20,600 mg/kg) were excluded from the risk assessment. The rationale provided was as follows: "Anglin Bay is an area not expected to encounter much use in terms of wading or even swimming and thus these depth samples are unlikely to be available to pose risk to humans." However, text on page II-2 (Chapter IV) states that the docks located near the LaSalle Causeway and Anglin Bay are often used for swimming and other water-related recreational activities. We agree that exposure to the deeper sediments with elevated PAH concentrations is unlikely provided they are not exposed due to disturbance of surfícial sediments (e.g., due to prop wash). Further rationale for excluding these samples is recommended, including confirmation that the area of contamination has been delineated (including data for the surfícial sediments in the area), the location of the sediments relative to areas where people are expected to swim or wade and confirmation that the surfícial sediments overlying the sediments with "extremely high PAHs" are not expected to be disturbed. If these sediments are excluded from the risk assessment, they may still need to be risk managed to ensure that they do not become exposed/uncovered (e.g., if overlying sediment were to be dredged, these deeper sediments with substantially higher PAH concentrations could become exposed).

- Response Category 3.
- Response HC-2014-018 – See response HC-2014-017 above. The clear distinction between present-day risks based on near-surface chemistry, versus potential risk scenarios through sediment disturbance, needs to be made. In the case of sediment PAHs, the very high concentrations of PAHs in some samples (i.e., hazardous waste) also warrant consideration in the remedial options analysis.

HC-2014-019

[Chapter IV - Defining Exposure Point Concentrations] • As noted previously by Health Canada in comments provided in a letter dated June 18, 2010 and by Golder Associates in their technical memorandum dated March 31, 2014, dioxin-like PCBs are not explicitly addressed in the risk assessment. The report does not note whether dioxin-like PCB congeners have been analyzed in sediments in the lower KIH. OMOE (2010) report congener specific PCB concentrations in their report Cataraqui River Project Track-Down: Follow-up Study on Success of Remediation Efforts in the Cataraqui River 2006. If sufficient data are available, they should be considered in the risk assessment. If the data are not available, the potential implications of this data gap should be considered and discussed in the risk assessment. If any future sediment sampling is planned for the lower KIH, consideration should be given to analyzing a subset of samples for dioxin-like PCB congeners, if warranted.

- Response Category 2.
- Response HC-2014-019 – We would like to discuss this issue with Expert Support, given that previous feedback has been that Health Canada does not evaluation dioxin-like PCBs as carcinogens, but rather as non-carcinogens using the hazard quotient method. However, methods for assessing dioxin-like PCBs quantitatively is possible for wildlife risk assessment (e.g., application of CCME tissue guidelines for TEQs).

HC-2014-020

[Chapter IV - Defining Exposure Point Concentrations] • Hg in fish: Map III-9 seems to show the highest concentrations of Hg in juvenile yellow perch in the area adjacent to the Kingston rowing club, which is within the area of highest contaminant concentrations. Is it possible that fish within the areas of the harbour with highest Hg concentrations in sediments may have higher concentrations of Hg in tissue? If this is the case, and if it is possible that some people may primarily fish within this area, the use of the 95% UCLM for all fish tissue from the inner harbour may underestimate risks for some receptors.

- Response Category 2
- Response HC-2014-020 – This issue should be discussed in the context of defining management areas. There are several interrelated issues including the degree to which fish collections may reflect localized contamination, the degree to which the fish foraging patterns would smooth out such differences over time, and whether human use patterns would smooth out concentration differences.

HC-2014-021

[Chapter IV - Defining Exposure Point Concentrations] • Fish data were not separated by species. If some people may have a preference for a particular species they may consume only one species rather than an average of all species. The report does not include summary statistics for individual species. Therefore, it is not clear whether contaminant concentrations in tissue of any one species may be significantly higher than others. The potential for higher risks associated with selective consumption of the species with the highest concentrations (rather than equal consumption of all species) may need to be explored if it has not already been considered.

- Response Category 2
- Response HC-2014-021 – It is common in HHRAs to make simplifying assumptions regarding the dietary preferences of recreational fishers, either through use of an indicator representative species (or combination of species), or through the assumption that measured concentrations in all harvested fish are representative of typical exposure. In this site context, it difficult to define any specific scenario as being optimal. We would like to liaise with Expert Support for guidance on how to incorporate the variations in fish concentration data without making unrealistic or overly conservative assumptions for species preference.

HC-2014-022

[Chapter IV - Surface Water Data] • Maps showing surface water sampling locations are not provided in the report (references are provided to other reports where they can be found). Therefore, we could not determine where samples were collected or the surficial sampling program covered sufficient and appropriate areas of the KIH.

- Response Category 4 or 5.
- Response HC-2014-022 – Comment relates to RMC-ESG deliverable; this remains as an uncertainty.

HC-2014-023

[Chapter IV - Surface Water Data] • Surface water data is presented only for a subset of the inorganic COPCs (Table IV-8). In particular, data for mercury, antimony or arsenic were not presented in Table IV-8 and it is not clear whether they were analyzed in surface water. If they were analyzed, it is not clear why they are not included in Table IV-8 and the interpretation of surface water data. If they were not analyzed, it is not clear why.

- Response Category 5.
- Response HC-2014-023 – We cannot address this issue without provision of surface water chemistry data from RMC-ESG (assuming that such data exist). Although it is likely that other risk pathways (sediment and dietary exposure) are more important for these parameters, the lack of clear water column screening remains as an uncertainty.

HC-2014-024

[Chapter IV - Surface Water Data] • Surface water samples were analyzed for both total and dissolved metals. The maximum total metals concentrations for lead, zinc and chromium were higher than Ontario Drinking Water standards and Canadian drinking water quality guidelines (CDWAG) (lead and chromium exceeded the Canadian drinking water quality guidelines by several orders of magnitude); however, maximum dissolved concentrations were below both the Ontario standards and the CDWAG. The report indicates that because the dissolved phase constituents were below guidelines/standards and because exposure to suspended solids is evaluated separately, exposure to COPCs in surface water is not considered as a pathway.

It is reasonable to evaluate human exposure to suspended sediments separately as people would be expected to disturb the sediments while wading/swimming in shallow water and be exposed to a higher suspended sediment concentration than that measured in surface water samples (which are typically collected in a manner that would minimize the amount of suspended solids in the sample). However, it may also be useful to evaluate risks associated with consumption of surface water during recreation based on total COPC concentrations in surface water as a check for comparison with the estimates based on predicted exposure to suspended sediments.

- Response Category 2.
- Response HC-2014-024 – We agree that comparisons of water concentration data should be made to Canadian drinking water quality guidelines using the total concentrations (not dissolved). We will reassess the screening procedure on this basis. With respect to the the calculation of dose in the HHRA, there are multiple choices available for breaking down the total xposure (e.g., suspended sediment combined with water, or separated out as a distinct exposure medium). What is most important is that the parameters assigned to these media (ingestion rates, and concentration estimates) be reasonably reflective of the receptor scenario of interest. We would like to consult with Health Canada on some of the ingestion rates, including incidental sediment ingestion and water ingestion, as the tabulated values in Table IV-13 appear over-conservative.

HC-2014-025

[Chapter IV - Surface Water Data] • It is not clear whether the reference data for surface water are for total or dissolved constituents. Therefore, it is not clear how the data from KIH compare with the reference data. With the exception of zinc, the maximum concentrations of dissolved data are very similar to those for the reference site for each of the parameters shown on Table IV-8.

- Response Category 5.
- Response HC-2014-025 – Will be addressed in upcoming risk refinement, provided that RMC-ESG can provide assistance in determining units for these data.

HC-2014-026

[Chapter IV - Exposure Media] • The report states that there are no beaches or formal bathing areas in the KIH and that people would only be exposed to sediments that are submerged under water. Transport Canada and Parks Canada may wish to confirm that there are no beach-like areas within their water lots and that water level fluctuations do not occur that would expose the contaminated sediments resulting in exposure similar to that in the tidal flat or on a beach.

- Response Category 3
- Response HC-2014-026 – Requires liaison with Expert Support, and perhaps other parties. The distinction between permanently wetted sediments and those that may be exposed (dry) intermittently along the shoreline has implications for several HHRA parameters, particularly dermal absorption. One approach would be to discuss potential beach formation in the uncertainty assessment vis-à-vis future exposure scenarios and level of conservatism. Also can confirm with Parks Canada and Transport Canada what is known about current human use/access or future scenarios. It appears that dry contact with sediments was not included in the RMC-ESG assessment (whereas wet contact with submerged sediments was); our approach for the risk refinement will be to confirm the assumptions, determine if beach like conditions can or could exist, and discuss implications in uncertainty assessment.

HC-2014-027

[Chapter IV - Exposure Media] • In their response to Health Canada comments on a previous version of Chapter IV (dated November 5, 2010 and included in Appendix M of the report) Environmental Sciences Group (ESG) notes in comment 16 that "potential direct exposures to bulk dry sediments (such as exposures at a beach) are included in the risk assessment". As noted above, this type of exposure was not included in the risk assessment as there are reportedly no areas of exposed sediments in the lower KIH.

- Response Category 1b.
- Response HC-2014-027 – Agree that statement is confusing; will confirm if they are or are not included and explain.

HC-2014-028

[Chapter IV - Exposure Duration and Amortization] • The exposure scenario evaluated is for a person visiting the KIH daily for the months of July and August (for a total of 61 days). It is not clear why receptors would not be expected to visit the site in June or September. Also, the assumption of daily exposure during warmer months may need to be revisited. It appears that there may be residential areas in close proximity to the western shore of the KIH and residential developments are reportedly planned for the undeveloped portions of the western shore. However, the current physical setting does not reportedly include beaches or other areas that would encourage frequent, repeated wading and swimming.

- Response Category 2.
- Response HC-2014-028 – We will recommend adjusting the amortization for non-carcinogens (longer than 2 months) but also reducing the frequency of site use (less than daily) – the overall risk is a balance between these considerations. Specification of a single scenario that is considered appropriately protective of a population is challenging, particularly when usage patterns may change with foreshore redevelopment.

HC-2014-029

[Chapter IV - Exposure Duration and Amortization] • Exposure Amortization: Direct contact exposure was assumed to occur daily for 61 days during July and August. This exposure period was amortized over the entire year to estimate exposure. Please note that exposure amortization should be completed on a chemical specific basis with sufficient rationale. In this case, we recommend that the exposure for non-carcinogens be amortized only over the period during which exposure may occur (in this case July and August), unless rationale can be provided for an alternate approach. As noted in the previous comment, the assumption of daily exposure during the entire exposure period could be revisited to evaluate whether it would be reasonable or overly conservative.

- Response Category 2.
- Response HC-2014-029 – See response HC-2014-028 above – similarly, an assumption of more months per year, but with fewer visits per month may be appropriate.

HC-2014-030

[Chapter IV - Exposure Duration and Amortization] • Fish consumption rates were developed based on information from the OMOE (2006) document 2003 Guide to Eating Ontario Sport Fish Questionnaire which is relevant for fish consumption in the Great Lakes. The meal size of 236 g/meal and the consumption frequency of 39 meals/year were used to derive an average daily consumption rate of 24.9 g/day. This results in a significant amortization of exposure to COPCs in fish tissue. Also, it is not clear whether respondents of the OMOE Sport Fish Questionnaire consumed the 39 meals throughout the year (e.g., some fish were frozen for future consumption) or whether consumption was concentrated primarily within a limited fishing season. We recommend that exposure amortization be completed on a chemical and site-specific basis with supporting scientific rationale. The significance of the exposure amortization inherent in developing the average daily consumption rate should be discussed in the risk assessment. If further work is to be done to refine risk estimates for the lower KIH, we recommend contacting OMOE for further guidance on evaluating exposure to COPCs through consumption of impacted sport fish.

- Response Category 2.

- Response HC-2014-030 – Similar to responses HC-2014-028 and -029 above, it is challenging to provide exposure amortization “on a chemical and site-specific basis with supporting scientific rationale.” The scenario provided is simplified given the lack of site-speciifc information, and it is likely that a scenario of more months per year (i.e., longer fishing and consumption season) is reasonable. However, this begs the question of whether the number of meals per month would also need to be adjusted to compensate. Given that previous advice from Health Canada on earlier RMC-ESG documentation resulted in reduced ingestion rates, it is not clear whether Health Canada is concerned about the specific details of rationale/methods, or with the final tissue ingestion rate, or both.

HC-2014-031

[Chapter IV - Exposure Parameters] • Dermal Adherence: Dermal adherence factors for sediments reported by Shoaf et al (2005) were used to evaluate exposure to bedded sediments submerged under water and soil dermal adherence factors from Health Canada PQRA Part I (2012) were used to evaluate exposure to suspended sediments. Please note that there is significant uncertainty associated with the use of the Shoaf et al (2005) dermal adherence factors to estimate dermal exposure to bedded sediments submerged under water. The Shoaf et al (2005) values were estimated based on a study of children playing in a tidal flat comprised of primarily medium sand with an organic carbon content on the order of 1% to 2%. The children in the study were in contact with both submerged (including bedded and suspended) and exposed sediment and the bulk of the adhered sediments is presumably from contact with the exposed sediments rather than the submerged sediments. The exposure scenario evaluated for the KIH involves people playing in shallow water where they are exposed only to submerged (bedded and suspended) sediments that are reported to be comprised of primarily silt and clay with a relatively high organic carbon content (greater than 10% in some locations). If people were expected to be in contact with exposed sediments (i.e., not submerged under water) along the shoreline of KIH, the adherence values reported by Shoaf et al (2005) would likely underestimate exposure due to the nature of the sediments (very fine grained with high organic carbon content). However, there are reportedly no exposed sediments along the shoreline and the risk assessment evaluates exposure only to bedded sediments submerged under water and suspended sediments in surface water. Submerged and suspended sediment would not be expected to adhere to the same degree as exposed sediment and a significant portion of submerged and suspended sediment would be expected to wash off as people exit the water. Overall, both the Shoaf et al (2005) dermal adherence factors and the Health Canada (2012) soil dermal adherence factors are expected to overestimate dermal adherence for people playing in the water in KIH. Given that the dermal pathway is a significant contributor and/or driver of risk for most COPCs, consideration should be given to refining the dermal exposure estimates. We are not aware of any published dermal adherence factors relevant to a scenario where people are exposed only to sediments submerged under or suspended in water. Careful consideration should be given to selecting adherence factors for this scenario. Also, if dermal exposure is re-evaluated, one potential approach would be to use one set of dermal adherence factors to estimate combined adherence of both bedded sediments submerged under water and suspended sediments in water, rather than considering them separately and adding the exposures. This may be reasonable since exposure to bedded and suspended sediments in water would generally occur simultaneously for receptors playing in shallow water along the shoreline and the existing dermal adherence factors likely overestimate adherence for both bedded and suspended sediments in water.

- Response Category 2.
- Response HC-2014-031 – We agree that the dermal adherence factors require careful consideration in recognition of the data sets available and their relevance to the plausible exposure scenarios for KIH. We have summaries of dermal adherence factors, including data from Shoaf, Kissel, and other authors, but the correspondence to a submerged exposure scenario is weak, even before substrate differences are taken into account. We agree with Expert Support that the existing dermal adherence factors likely overestimate adherence for both bedded and suspended sediments in water, but require guidance for making more realistic estimates.

HC-2014-032

[Chapter IV - Exposure Parameters] • No rationale was provided for the use of the Health Canada (2012) soil dermal adherence factor for evaluating exposure to suspended sediments. Also, it is not clear why the Shoaf et al (2005) values were used for hands and feet but the soil values from the PQRA were used for arms and legs as Shoaf et al (2005) report values for arms and for legs. In any subsequent analysis of dermal exposure, sufficient rationale should be provided for the selected dermal adherence factors.

- Response Category 1b.
- Response HC-2014-032 – See response to HC-2014-031, above. Once we sort out the exposure factors above, the specific concerns raised in this comment can be addressed, and rationale provided.

HC-2014-033

[Chapter IV - Exposure Parameters] • Sediment Ingestion rates: The exposure scenario evaluated for the KIH involves a receptor wading and swimming in the near-shore water, where they may be exposed to COPCs in sediments submerged under water, including suspended sediments and bedded sediments. Table IV-13 cites sediment ingestion rates of 200 mg/day for toddlers and 100 mg/day for adults. At the time that the original risk assessment was completed in 2010, these values were recommended by Health Canada as a conservative approximation of sediment ingestion rates for people in contact with exposed sediments (i.e., not submerged under water). Given that people are not expected to be in contact with exposed sediments (e.g., beach sediments), incidental ingestión of sediment would likely occur primarily via incidental ingestion of suspended sediment in surface water while playing in the water. Incidental ingestion of bedded sediments is not expected to be significant. Therefore, it appears that the sediment ingestion rates of 100 mg/day for adults and 200 mg/day for children would not be relevant for the site. Please note that Wilson and Meridian (2011 and 2013) developed sediment ingestion rates for Health Canada under contract and a manuscript is currently being developed for publication. Rates were developed for hand-to-mouth contact with exposed sediments that are notsubmerged under water (e.g., intertidal sediments or beach sediments) and for incidental ingestion of suspended sediments in surface water. The proposed rates are on the order of 72 mg/hour and 20 mg/hour for children and adults, respectively for incidental ingestion of exposed sediments due to hand-to-mouth contact and 8 mg/hour for all receptors for incidental ingestion of suspended sediments during in-water recreational activities. Based on the exposure time of 73 minutes/day selected for swimming/shoreline play in KIH for toddlers and adults, these rates would correspond to daily rates of 88 mg/day for toddlers and 24 mg/day for adults for incidental ingestion of exposed sediment via direct contact and 10 mg/day for ingestion of suspended sediments. The total exposure for people visiting the KIH via sediment ingestion is likely highly overestimated as ingestion of bedded sediments submerged under water is expected to be insignificant. If sediment ingestion rates were re-evaluated based only on ingestion of suspended sediments, it is recommended that the values proposed by Wilson and Meridian be considered, rather than the lower suspended sediment rates (1.5 mg/day) used in the HHRA.

- Response Category 1b – Being addressed in upcoming risk refinement.
- Response HC-2014-033 – In the absence of an official Health Canada procedure, we agree that sediment ingestion rates from Wilson and Meridian (2011 and 2013) provide an improved basis for evaluating this pathway, and should replace the over-conservative estimates originally assigned. We propose to use these recent estimates, acknowledging that the hourly estimates require assumptions regarding the number of hours per day spent recreating for each receptor. We propose to apply estimates of hours of exposure per day for toddlers and children (2 hours/day) and teens/adults (4 hours/day).

HC-2014-034

[Chapter IV - Toxicity Reference Values] • The source of the chlordane TRV is not clear.

- Response Category 1a
- Response HC-2014-034 – RMC report Table IV-16 references an oral tolerable daily intake (TDI) of 3.3 x 10^{-5} mg/kg-day for chlordane, and Appendix J (Section C – Chlordane) indicates that this value was obtained from OMOE (2011). OMOE (2011) indicates the TRV is a non-cancer child-specific reference dose (chRD) derived by the California Environmental Protection Agency (CalEPA 2005). The chRD is based on a 1994 study where changes in sex-steroid mediated behaviours were observed in male and female rats following pre- and post-natal exposure to chlordane (Cassidy et al. [1994], as cited in CalEPA 2005). A chlordane dosage of 0.1 mg/kg-day was found to disrupt sex hormone mediated behaviours and was identified as the lowest observed adverse effect level (LOAEL). CalEPA applied a total uncertainty factor of 3,000 (10 for interspecies variability, 10 for human variability and 10 to extrapolate from a LOAEL to a NOAEL, and 3 to account for database deficiencies) to the LOAEL to calculate the cHRD.

CalEPA (California Environmental Protection Agency). 2005. Development of Health Criteria for School Site Risk Assessment Pursuant to Health and Safety Code Section 901(g): Child-Specific Reference Doses (chRDs) for School Site Risk Assessment - Cadmium, Chlordane, Heptachlor, Heptachlor Epoxide, Methoxychlor, and Nickel. Final Report, December 2005. Integrated Risk Assessment Branch, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. Available at http://oehha.ca.gov/public_info/public/kids/pdf/FinalSchoolReport121205.pdf.

OMOE (Ontario Ministry of the Environment). 2011. Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Sites in Ontario. Prepared by Standards Development Branch, OMOE. April 15, 2011. Available at https://www.ontario.ca/environment-and-energy/rationale-development-soil-and-ground-water-standards-use-contaminated-sites.

HC-2014-035

[Chapter IV - Toxicity Reference Values] • The Contaminated Sites Division (CSD) of Health Canada currently does not endorse a toxicity reference value (TRV) for lead for use in human health risk assessments at contaminated sites. The previous value in Health Canada's guidance - a tolerable daily intake (TDI) of 3.6 µg/kg-day - is no longer recommended for use within contaminated site risk assessments. We also no longer recommend the use of the OMOE TDI of 1.85 µg/kg-day. These TDIs were based on a value from JECFA/WHO, which has been withdrawn by JECFA as it was considered that the value was unlikely to be protective of human health (JECFA, 2010). Until the review of the toxicology of lead is completed by Health Canada, it is recommended that qualified risk assessment professionals identify a TRV for lead from another regulatory agency. Alternate TRVs, including values from the California OEHHA (2007; 2009) or JECFA, may be used in quantitative risk assessments at federal contaminated sites, with appropriate scientific rationale.

- Response Category 2.
- Response HC-2014-035 – We agree that, pending the review of the toxicology of lead by Health Canada, an alternate for lead should be drawn from another regulatory agency. We are proposing to use an alternative TRV based on a recent SNC-Lavalin assessment of lead toxicity to adults, infants, toddlers, and children. Their assessment resulted in a TRV based on WHO (2011) assessment, a conclusion consistent with the withdrawal of the WHO (2010) value by Health Canada.

HC-2014-036

[Chapter V - Need for Management Actions: Summary of the Main Outcomes from Chapters II, III and IV] • It is noted on page 1-2 that "the toxicity thresholds do not account for possible synergistic effects resulting from the complex mixture of contaminants in the APEC" and that the assessed risk may therefore be "greatly underestimated". The term "greatly" is not qualified with supporting text and although this statement on possible synergistic effects appears to be related to assessed ecological risk (i.e. to the brown bullhead fish), it undermines one of the report's major messages (i.e. that it is now time for management actions) since the management actions may not mitigate the currently unknown risks to receptors from chemical mixtures. Furthermore, there does not seem to be any initiative to assess possible synergistic effects of the complex chemical mixture on health risk to humans. Given the complexity of the chemical mixture, the challenges inherent to managing any assessed risk (likely a combination of management actions) and the goals of risk mitigation (i.e. to reduce risk to receptors), assessment of chemical mixtures or perhaps further consideration in an uncertainty analysis, may be considered.

- Response Category 4.
- Response HC-2014-036 – This comment, which we agree with, appears to relate to narrative that is specific to the RMC-ESG deliverable. However, the broader implications of the comment link to the degree of certainty we can have that remediation drivers have been appropriately identified. Given the challenges in evaluating interaction effects for both human health and ecological receptors, this issue is best dealt with in the uncertainty analysis.

HC-2014-037

[Chapter V - The Framework for Addressing and Managing Contaminated Sites Under the Federal Contaminated Sites Action Plan] • There is a footnote on page II-1 that refers to "Section 6.1.1.2 of Treasury Board Guidelines" that not only does not provide a reference, but also selectively and incompletely quotes Treasury Board Policy. The lack of proper reference makes the content difficult to verify by the reader.

The text is in fact a slightly refined (text omitted) exact quote of Section 6.1.12 (not 6.1.1.2, which does not exist) of the Treasury Board (TB) Policy on Management of Real Property (effective November 11, 2006). The most notable omission is the word "federal" that should be present in the sentence, "Management activities (including remediation) must be undertaken to the extent required for current or intended federal use." The other omission from the TB Policy is "...or requirements that may be applicable abroad" in the sentence: "These activities must be guided by standards endorsed by the CCME or similar standards or requirements that may be applicable abroad." It is recommended that any inaccurate interpretations made in the report text as a result of the omissions be corrected.

- Response Category 4
- Response HC-2014-037 – This comment is specific to the RMC-ESG report.

HC-2014-038

[Chapter V - The Framework for Addressing and Managing Contaminated Sites Under the Federal Contaminated Sites Action Plan] • On page II-2, it is noted that completion of the ASCS Pre-screening Checklist led to an automatic Class 1 designation for the site and that the worksheets were completed for "comparative purposes". It should be noted that current guidance specifies that "A site scored as Class 1 using only the pre-screening checklist will not be considered eligible for FCSAP R/RM funding without the completion of the remaining NCSCS or ASCS worksheets for eligibility review." Nevertheless, the full scoring completed by ESG ultimately did score the site as Class 1.

- Response Category 4
- Response HC-2014-038 – Our scope does not include NCSCS or ASCS classification; however, our scoring at DQRA stage also identified a Class 1 designation.

HC-2014-039

[Chapter V - The Framework for Addressing and Managing Contaminated Sites Under the Federal Contaminated Sites Action Plan] • There does not seem to be any justification given on page 11-17 for the statement, "...it is unlikely that [combined sewer overflow] effluent contains high levels of contaminants such as Cr and PCBs..." i.e. there should be justification qualifying why this is unlikely.

- Response Category 4
- Response HC-2014-039 – This comment is specific to the RMC-ESG report.

HC-2014-040

[Chapter V - Analysis of Management Options] • On page III-6, the dredging management option is selected as the preferred remediation strategy in part due to its "likely effectiveness"; however, the statement is not supplemented by supporting documentation that demonstrates its effectiveness for the site in question. Furthermore, the statement on page III-7 that "dredging does not require long-term maintenance or post-remediation performance monitoring" can be misleading since performance effectiveness would need to be monitored and thus demonstrated, as is indicated in Table V-I, page II-7, Risk Management Principle #11.

- Response Category 4
- Response HC-2014-040 – This comment is specific to the RMC-ESG report.

HC-2014-041

[Chapter V - Analysis of Management Options] • There is little discussion regarding prevention of recontamination of any dredged areas by adjacent contaminated sediments. Accordingly, the management options analysis should have identified mitigation measures to ensure/minimize the dredged areas becoming impacted by adjacent sediment. Furthermore, the analysis of management options only considers the management options in isolation of one another not taking into considerations innovative and integrated solutions. Management options may ultimately involve a combination of the various methods available (no action, institutional controls, monitored natural recovery, capping, dredging, etc.), since the site is complex in its contaminant profile and physical/chemical/biological processes and issues and goals are geographically unique.

- Response Category 4
- Response HC-2014-041 – This comment is specific to the RMC-ESG report.

HC-2014-042

[Chapter V - Sediment Management Goals for the KIH] • The spatially weighted average concentration (SWAC) methodology and, in particular, the procedure for calculating the area of the harbour "requiring management" for each COC, are not explained in clear enough detail for the reader and there is a lack of supporting calculations. Also, the discussion regarding SWACs for various COCs seems out of place on page IV-11, as it appears in a section dedicated to deriving Sediment Quality Objectives (SeQOs) for PCBs.

- Response Category 1b
- Response HC-2014-042 – In the risk refinement, exposure point estimates (and supporting statistics) with be provided for each management zone.

HC-2014-043

[Chapter V - Sediment Management Goals for the KIH] • The rationale for the choice of the boundaries of the PAH management zone lacks clarity. In fact, there doesn't seem to be a complete rationale justifying the footprint of the ultimately proposed management areas. Also, the ESG overall proposed management area excludes most of the area, i.e. in and around Anglin Bay, that Golder (2012) had previously identified as being the best candidate for active management based on evidence gathered by them to-date.

- Response Category 1b
- Response HC-2014-043 – We agree with the comment. The boundaries for the PAH management zone may have been defined based on an acknowledgement that HQs could not be reduced to below one without identification of a large volume of sediment. The risk refinement will contain several changes to the exposure parameters that will influence HQs (on an area-specific basis).

HC-2014-044

[Chapter V - Sediment Management Goals for the KIH] • Given the spatial extent and levels of contamination in sediments (Maps II-6 to 11-16) adjacent to the SWAC zones shown in Maps V-I to V-8 (and the proposed PAH shoreline management area), it would appear likely that contaminant levels in dredged zones would gradually increase above the proposed SeQOs through sediment movement due to waves, wind, propeller wash, etc. Furthermore, the sediment movement patterns appear to be poorly understood and study of sediment movement can be considered a prerequisite to finalization and implementation of the ultimate management strategies. It is not understood how long the contaminant levels in the proposed management zone (Map V-8) will remain within the SeQOs and also how the risk would change as contaminant levels gradually rise above those SeQOs. Also, there is little or no sediment data available for the sediments in the marina area and the data along the shoreline north of the marina is very sparse. If TC was to consider doing any additional sediment sampling, these areas would warrant further investigation. The lack of data in that area is also of concern as this elevated contamination is outside the proposed management area and potential human health risks may not be properly and completely assessed or mitigated.

It would seem appropriate that one of the goals in any remedial strategy would be that a managed or dredged area does not become recontaminated, such that future site use does not result in new risks to human health.

- Response Category 4
- Response HC-2014-044 – This comment relates to the proposed sediment stability study and to evaluation of reliability and effectiveness of dredging, both are which are important but beyond our current scope.

HC-2014-045

[Chapter V - Sediment Management Goals for the KIH] • It is not clear whether the exposure point concentrations (EPCs) were derived from sediment data for all depths or whether only certain depths were considered. ESG notes that two samples at depth with exceptionally high PAH concentrations in one area and two samples at depth with exceptionally high antimony concentrations in another area were not included when the EPCs were developed. It would thus appear that all data were included regardless of depth (except the aforementioned four samples). If TC were to develop a revised HHRA, they could consider whether they can define a depth at which exposure would no longer be expected (i.e., people and aquatic organisms would not come into contact with these sediments as they are buried and are at a depth where they are not expected to be exposed as a result of regular activities and conditions in the harbour). They could consider excluding the data from below this depth from the statistics used to define EPCs. Any contamination at depth that is excluded from the risk assessment would need to be risk managed and it would need to be ensured to the extent practicable that the sediments remain buried. If it is later proposed that they be exposed (e.g., due to dredging), they would need to be incorporated into the risk assessment and/or managed appropriately.

- Response Category 1b
- Response HC-2014-045 – Agree with comment. Per the advice, for risk assessment, we will define a depth at which exposure would not be expected, but will retain understanding of contamination at depth as part of remedial options evaluation.

HC-2014-046

[Chapter V - Sediment Management Goals for the KIH] • Although responses to reviewer comments (Appendix M) allude to some of the changes made in the revised report, it would be helpful if the report author could provide additional supporting documentation for those changes and point out/justify any changes made that weren't addressed in the documented responses to reviewer comments.

- Response Category 4
- Response HC-2014-046 – Comment relates to RMC-ESG deliverable only.

HC-2014-047

[Chapter V - Residual Risk and Uncertainty Analyses] • As noted in this review, there are additional uncertainties that need to be considered that are not considered here (discussed elsewhere in this review).

- Response Category 1b.
- Response HC-2014-047 – To be addressed in uncertainty analysis.

HC-2014-048

[Chapter V - Considerations for RAP Design] • Ongoing site and risk assessment studies will be required prior to development and implementation of a remedial action plan (RAP). The text is correct to note that uncertainties are present and need to be addressed.

- Response Category 4
- Response HC-2014-048 – We agree.

HC-2014-049

[Chapter V - Conclusions and Recommendations] • As noted earlier, contrary to the assertions in the ESG report (reiterated in the Conclusions and Recommendations), based on this review and the review completed by Golder, there appears to be considerable work remaining before developing and implementing a remedial action plan for KIH.

- Response Category 4
- Response HC-2014-049 – We agree.

HC-2014-050

[Chapter V - References] • The reference section does not include the required reference to the Treasury Board Policy on Management of Real Property

- Response Category 4
- Response HC-2014-050 – Comment relates to RMC-ESG deliverable only.

HC-2014-051

[Chapter V – Minor Comments] • The text on page 11-19 notes that among the 4 SARA species of turtles, some have "endangered" status; however, none of the 4 turtles listed in Table V-3 on page 11-20 are noted to be endangered.

- Response Category 1b
- Response HC-2014-051 – Will be clarified as part of the assessment of listed and endangered species.

HC-2014-052

[Chapter V – Minor Comments] • The sediment stratigraphy of selected cores collected in the KIH is shown in figure V-l (not Figure V2 as noted in the text on page III-8).

- Response Category 4
- Response HC-2014-052 – Comment relates to RMC-ESG deliverable only.

HC-2014-053

[Chapter V – Minor Comments] • It appears that, for clarity, the title of map V2 should be "Arsenic Map of 6 ppm of surface sediments in KIH": the current title excludes "ppm".

- Response Category 4
- Response HC-2014-053 – Comment relates to RMC-ESG deliverable only.

HC-2014-054

[ESG Report Format and Geographical References] • The report is lengthy (1027 PDF pages) but does not provide PDF bookmarked sections or an overall table of contents. This makes the report extremely difficult to navigate and to find supporting tables, calculations and figures. Thus, it is suggested that these and other changes noted herein would improve the overall readability and accessibility of the report.

- Response Category 4
- Response HC-2014-054 – Comment relates to RMC-ESG deliverable only.

HC-2014-055

[ESG Report Format and Geographical References] • Another notable challenge with navigating the report stems from the fact that KIH is defined in the report Executive Summary as the stretch of the Cataraqui River between the 401 and the Lasalle Causeway. It would perhaps be more practical to define the KIH as the stretch of the Cataraqui River between Belle Island and the Lasalle Causeway since this appears to be a conventional reference and the bulk of the study area figures are labelled that way and only show that stretch. Furthermore, the area contains the federal water lots in question and the numerous unique and geographically separate zones of contamination. The lengthy stretch north of Belle Island to the 401 is spatially extensive, is labelled in part as the Rideau Canal (Figures 1-1 and I-2 in Chapter 1), and is considered to be uncontaminated and is not characterized in the report to the same extent (serves as background data for comparison with contaminated areas south of Belle Island).

- Response Category 2
- Response HC-2014-055 – Completely agree that we must be clear in defining the studied area, or sub-areas within. Would like to discuss with FCSAP to make sure that terminology is clear and broadly supported.

HC-2014-056

[ESG Report Format and Geographical References] • As noted in Golder's review, the southern area (between Belle Island and the Lasalle Causeway) is treated in the ESG report as a single exposure area or APEC, and the numerous contaminated zones that are spatially-separated and unique in their contamination issues are grouped together as the "southwestern KIH". It would be easier to locate/visualize specific issues/areas if the numerous unique contaminated zones were identified more frequently in the text in terms of their geographical (northwest, southwest, etc.) localization within this exposure area/APEC. Instead, the current text refers regularly to contamination by families of contaminants (i.e. metals, PAHs, etc.) and specific contaminants (chromium, mercury, etc.), in the "southwestern" KIH (i.e. southwest of Belle Island). This is very imprecise/ambiguous in geographical terms, given the numerous unique contaminated zones in the exposure area/APEC, including in its southwest portion.

- Response Category 1b
- Response HC-2014-056 – Our specification of new management areas, along with resolution of issue HC-2014-055 should take care of this.

6.2 Part B. Technical Memorandum – Review of Revised RMC Reporting on Kingston Inner Harbour Sediments prepared by Golder Associates (March 31, 2014)

HC-2014-057

The Golder memorandum is well written and is a good high level synopsis/analysis of the final ESG report and HC ES provides the following general comments.

- Response Category 1a
- Response HC-2014-057 – Thank you; no response required.

HC-2014-058

With reference to the Golder (2013) source investigation for the southwest TC water lot, Golder notes that recent findings have shown that in many areas, offshore PAH concentrations exceed those along the shoreline. Furthermore, it is noted that coal tar has historically been observed in core samples in the vicinity of Anglin Bay and that historical deposition of coal tar may be a significant source of PAH contamination within Anglin Bay sediments. This is important when considering management options related to PAHs and their impact on human health.

- Response Category 1b.
- Response HC-2014-058 – Agree with comment. Concentrations of PAHs in near-surface sediments will be addressed in upcoming risk refinement, both in terms of spatial distribution and associated risks to all receptor groups. Additionally, contamination at depth should be considered in future remedial options evaluation.

HC-2014-059

As noted by Golder, background exposure to PCBs does not appear to have been considered in the human health risk assessment, in identifying special management areas or in the development of sediment quality objectives. However, a hazard quotient of 1 was applied rather than the Health Canada default of 0.2 for risk estimates developed without consideration of background. The Health Canada default HQ of 0.2 is typically applied where background (off-site) exposures (e.g., from food, consumer products, water and air) have not been considered in order to minimize the chance that total exposure (site + background) does not exceed the tolerable daily intake. HC concurs that further justification should be provided for the use of a threshold hazard quotient other than 0.2 where background exposure is not considered.

- Response Category 2
- Response HC-2014-059 – Rather than apply the Health Canada default of 0.2 for risk estimates developed without consideration of background, it may be feasible to adjust exposure to include background sources. Because much of PCB exposure to urban residents in the Great Lakes comes through dietary consumption, use of a baseline ingestion for a typical resident could be added to the site-specific exposure from recreational exposure to KIH. This approach may yield a less conservative but more relevant estimate to use of default of 0.2.

HC-2014-060

Golder points out a number of areas where they concur with ESG, as well as several areas that they do not. Golder's review brings into question some of the methodologies employed by ESG in assessing health risks, and the conclusions and proposed management decisions drawn from obtained results. In this regard, our HC ES review of the ESG report is in line with the Golder review in that there still appears to be a lot of uncertainty with regards to the estimated level of risk to human receptors and what possible mitigations could be implemented to manage those risks to human health. HC ES concurs with Golder that additional work is needed with regards to assessing and managing contamination within the KIH in order to address those uncertainties and thereby more accurately characterize the risks to human health associated with KIH. To this end the ESG report is a valuable body of data that can potentially support additional assessment and management work on-site.

- Response Category 1b
- Response HC-2014-060 – Thank you; no response required.

Health Canada Santé Canada

Environmental Health Programme, RAPB
180 Queen St. W., 10th Floor
Toronto, Ontario M5V 3L7

February 6, 2015

Brent O'Rae
Contaminated Sites Ecologist
Parks Canada
635-8th Avenue South West, Suite 1550
Calgary, Alberta T2P 3M3

Dear Brent,

Subject: Review of Golder's responses on June 2014 Health Canada Comments on Kingston Inner Harbour Sediment Assessment

Health Canada reviewed responses to Health Canada comments (dated June 27, 2014) contained in the January 12, 2015 Technical Memorandum entitled *"Draft Responses to the FCSAP Expert Support Comments on Kingston Inner Harbour 2014 Reporting Package"* authored by Golder Associates, which is in response to FCSAP Expert Support comments on the RMC-ESG report entitled "*Application of the Canada-Ontario Decision-Making Framework for Contaminated Sediments in the Kingston Inner Harbour*" (dated February 2014) and on Golder's memorandum entitled "*Review of Revised RMC Reporting on Kingston Inner Harbour Sediments*" (dated March 31, 2014) and provides additional follow-up comments where warranted. The review was completed as per our role as an Expert Support Department under the Federal Contaminated Site Program (FCSAP). Our comments are attached.

From Golder's responses, we understand that the RMC-ESG document will not be revised (or that this is beyond Golder' scope or control) and that Golder will only work on a risk refinement deliverable. Regardless, several Health Canada comments related to the RMC-ESG document still stand and could be considered in the event of any future revision of this document, or could be included as part of an addendum to the current document (so that it is transparent which comments were and were not addressed). In addition, more specifics on what will be included or not in the upcoming risk refinement deliverable would be appreciated. It is recommended that all relevant information, calculations, assumptions, etc. regarding the human health risk assessment be provided in the risk refinement deliverable, to facilitate peer review and verification of assumptions. It could also be important for Transport Canada's and Parks Canada's health risk communication purposes to have a "stand alone" document that includes all pertinent data, assumptions, etc. As Golder Associates undertakes additional "risk refinement" work on behalf of Transport Canada and Parks Canada, Health Canada is able to provide advice and guidance on this site, where desired.

Please contact the undersigned if you have any questions with respect to these comments or human health risks and risk management for this site or any other sites.

Sincerely,

Adam Griffiths

Adam Griffiths, M.Sc.
Health Risk Assessment & Toxicology Specialist

cc: Adriana Glos, Environment Canada
Anita Wong, Environment Canada
Tara Bortoluzzi, Fisheries and Oceans Canada
Bertrand Langlet, Health Canada
Marie-Josée Poulin, Health Canada

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MEMO: Health Canada Review of Golder's responses on June 2014 Health Canada Comments on Kingston Inner Harbour Sediment Assessment

Document title: Draft Responses to the FCSAP Expert Support Comments on Kingston Inner Harbour 2014 Reporting Package
Document author: Golder Associates Ltd.
Document date: January 12, 2015
Reviewed by: Marie-Josée Poulin and Bertrand Langlet, Contaminated Sites Program, Health Canada
Date reviewed: February 6, 2015

Thank you for the opportunity to review and provide comments on the draft consultant responses to Health Canada comments contained in previous FCSAP Expert Support comments on two 2014 reports related to Kingston Inner Harbour (report on the application of a decision-making framework to contaminated sediments and a report on Kingston Inner Harbour sediments); responses were contained in the above mentioned document.

Health Canada provides these comments as per our role as an Expert Support department for the Federal Contaminated Sites Action Plan. These comments are in no way to be interpreted as any type of approval, authorization, or release from requirements to comply with federal statutes and regulations.

HC Follow-Up Comments on Golder's Responses dated January 12, 2015			
Reference Number	**Original HC Comment (June 27, 2014)**	**Golder Response (January 12, 2015)**	**HC Follow-up Comment (February 6, 2015)**
HC-2014-001	Our understanding is that, with the exception of perhaps some early studies, this report has generally not been prepared on behalf of, or funded by, either of the Custodial departments (Parks Canada (PC) and Transport Canada (TC)) that own the Kingston Inner Harbour (KIH) water lots that comprise the main study area. Health	Category 1b - Agree with comments; such concerns have resulted in the risk refinement report being conducted.	Satisfactory response. No further comment.

	Canada (HC) in its FCSAP Expert Support (ES) role continues to support these custodial departments by providing human health related comments on ongoing KIH reporting, at their request. It is noted that, although ESG has to a limited degree made an effort to incorporate a selection of the more recent work completed by others on behalf of the custodial departments, the ESG report uses wording that implies that there is a general consensus that the ESG report is the definitive study regarding the KIH, that its methodology and conclusions have been adopted and that the next steps in KIH sediment management are evident as a result. Concurrent KIH studies completed on behalf of TC (Golder, 2011, 2013, 2104, etc.) indicate that this is not accurate. Furthermore, PC and TC have indicated that human health and environmental site and risk assessment is ongoing and that support from ES Departments (ESDs, i.e. EC, HC and DFO) will continue to be sought as the Custodians manage their respective water lots.		
HC-2014-002	We have focused our review of the ESG report on the parts of the report relating to our mandated areas (i.e. potential risk to human health) and other ESDs have done	Category 1b - Following review of the full FCSAP Expert Support comment package, we agree that decisions may be significantly affected. At the same time,	Satisfactory response. It is suggested to consider issues that may significantly impact the human health risk assessment outcomes

	the same with regards to their mandates. Based on a review of the human health related sections of the above noted documents, HC recommends that the results of the human health risk assessment (HHRA - Chapter IV of the ESG Report) and the management options analysis (Chapter V of the ESG report) be considered within the context of the comments provided herein, as some comments are significant in nature and thus may impact the interpretation of the HHRA and any decisions stemming from it.	we do not have the scope to repeat or revise all aspects of the RMC-ESG risk assessment, nor do we believe that such is warranted. Instead, we recommend that select key assumptions/parameters be revaluated quantitatively, focussing on those decisions that most significantly influence risk outcomes, and we are soliciting additional Expert Support input on some of these topics. The overall objective is to evaluate the consequences for overall risk characterization; in some cases this will entail revision of HQ estimates whereas in other cases a narrative discussion in the uncertainty assessment will suffice.	and resulting decisions on next steps in KIH sediment management.
HC-2014-003	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • With the exception of antimony, the suite of metals included in the list of COPCs for the lower Kingston Inner Harbour (KIH) appears to be limited to those with Canadian Council of the Ministers of the Environment (CCME) sediment quality guidelines. The report includes raw data and a summary of sediment data only for the COPCs (i.e., maximum, minimum, mean and 95% upper confidence limit of the mean {UCLM}) and it is not clear whether other metals were analyzed or considered in the	Category 1b - Additional screening information will be provided in the risk refinement deliverable. Where CCME guidelines are not available, we will consider comparisons to sediment guidelines from other jurisdictions, soil guidelines if necessary, and will consider whether substances associated with relevant industrial activities have been captured in the screening (e.g., Health Canada Part I *Table A2 Contaminants Commonly Associated with Various Governmental and Industrial Activities*).	More details are needed on selection of COPCs before agreeing with Golder's response. Please note that, to ensure an approach that is fully coherent, rigorous and defensible regarding the objectives of an HHRA, Health Canada's Contaminated Sites Division recommends, for the identification of chemicals of potential concern (COPCs) on a particular site, a comparison of concentrations of chemicals against criteria that are protective of human health.

	COPC screening process. It appears, based on the summary of previous investigations in the KIH provided in Chapter II, that a full suite of metals has been analyzed for at least a subset of samples from the lower KIH. We also note that data for VOCs in sediment are reported for one sample from the KIH in a previous version of Chapter II, including relatively low but measureable concentrations of BTEX, isopropylbenzene and trimethylbenzene. Summary data for all substances measured in sediments in KIH should have been included in the report along with the screening values used and the corresponding data from the reference site, where applicable. Substances with no CCME screening value should be screened against appropriate screening values from other jurisdictions and/or data from reference sites, where available. In cases where no screening values are available, the substances should be carried forward as a COPC unless it can be clearly shown that concentrations in sediments in the lower KIH are not significantly different than those in the reference area and that there are no hot spots or areas with locally elevated sediment concentrations. Transport Canada and Parks Canada may wish to evaluate the raw sediment data from their respective properties to		Currently, there are no human health-based sediment criteria published from a Canadian jurisdiction. The few human health-based sediment criteria currently available from other jurisdictions would not be directly applicable to most Canadian federal contaminated sites as they generally do not consider all potentially relevant pathways. In some cases, in the absence of applicable human health-based sediment guidelines, sediment concentrations may be screened against available human health-based soil criteria for residential/parkland use <u>for a direct contact scenario</u>. These criteria were developed based on exposure factors specific to human interactions with soil. Given that human exposure to sediments is typically different from human exposure to soil (e.g., potentially greater dermal adherence and ingestion rates), the soil quality guidelines may not be sufficiently protective of human health for some sediment exposure scenarios. In particular, for a site where people are expected to visit the site

	determine whether any other substances should have been retained in the risk assessment.		regularly to participate in high contact-type activities (e.g., playing on the shoreline and in shallow water, picnicking, etc.) the soil quality guidelines may not be a sufficiently conservative screening tool. In this case, site-specific screening values could be derived. Alternatively COPCs may be identified by comparing site data with regional background data. In situations where soil quality guidelines are considered relevant and appropriate for screening, only the human health based guidelines for the relevant corresponding sediment exposure pathways should be considered. In particular, at many sites, incidental ingestion of and dermal contact with sediments may be the only operable pathways. In this case, only the human health-based soil quality guidelines for dermal contact and incidental ingestion would be considered relevant sediment screening values. In some cases, guideline values for inhalation of particulates may be relevant if sediments dry out periodically. For the purposes of screening federal sites, the relevant CCME

			Canadian Soil Quality Guidelines (SQG) for human health would generally be considered the most appropriate screening values. Where human health-based CCME SQGs are unavailable, human health-based soil quality guidelines from another jurisdiction may be selected provided they offer the same level of protection inherent in the CCME SQGs. In some cases, a guideline from another jurisdiction may need to be adjusted to account for differences in how the guidelines were developed, including health protection endpoints and the apportionment of the tolerable daily intake. In situations where the soil quality guidelines are used for screening, sufficient rationale must be provided for why the soil-based screening values are considered sufficiently conservative for screening sediments and the uncertainties associated with the selected criteria should be noted. Soil criteria do not account for the potential for chemicals to bioaccumulate or biomagnify in the aquatic food web. Therefore, they

			are not suitable for identifying bioaccumulative or biomagnifying substances that should be considered in evaluating risks associated with the consumption of seafood (i.e., fish, shellfish, aquatic vegetation or aquatic birds) from the site. COPCs for the seafood consumption pathway may be screened using the following approach: (1) Identify biomagnifying and potentially bioaccumulative chemicals that are site-related and present in sediments at the site above industry standard detection limits and above local background levels; (2) In some circumstances, screening based on sediment data may be supported by screening based on seafood tissue data. In particular, seafood tissue chemistry from the site may be compared to seafood tissue chemistry from a reference site, and/or applicable seafood

			screening criteria for the seafood consumption pathway, if available. To ensure that no additional COPCs should have been considered in the HHRA, it is suggested to review the selection of COPCs (by using human health-based environmental quality guidelines) or to justify the approach retained in this study and to identify its possible effects on the results.
HC-2014-004	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • The portion of the KIH north of Belle Island (i.e., the upper KIH) has been selected as the reference area. The report notes that this portion of the KIH has been minimally impacted by past industrial activities. The former Belle Park landfill forms part of the southern border of the upper KIH and it is not clear whether the former landfill has impacted sediments in this area as the former landfill is listed as a source of COPCs to the lower KIH. Also, it is not clear whether there were any other potential historical sources of contamination to the upper KIH. We note that the 95% UCLM for reference data appears to be higher than the Ontario sediment screening values and Ontario	Category 1b - Although there are a few areas north of Belle Island that exhibit sediment concentrations higher than in other reference areas, the vast majority of stations have exhibited concentrations of COPCs that are much lower than along the western half of the southern KIH. Furthermore, sampling of reference stations for effects data (e.g., benthic community assessment, toxicity testing) and for bioaccumulation assessment has emphasized the areas of the upper KIH that have been least influenced by urban contamination. As noted above, the retention of most substances (irrespective of the statistical comparisons to reference) means that risk characterization outcomes are not sensitive to the details of this screening. To address this concern,	Satisfactory response. No further comment.

	background concentrations for most metals and for PCBs. It appears that all sediment COPCs listed in Table II-2 and Tables IV-3JV-5, IV-7 were retained even if the data from the KIH was not considered significantly greater than the data from the reference area. Therefore, any issues related to the selection of sediment reference sites would not be expected to have any implications for overall findings of the human health risk assessment (HHRA) as they pertain to the COPCs that were presented in Chapter IV. If substances with no sediment screening values were compared with data from the reference area, the data from the reference area may need to be re-evaluated to confirm that there are no areas of localized contamination (e.g., adjacent to the former Belle Park landfill) that would bias the reference data high.	calculations of averages in the risk refinement will exclude data points that may reflect areas of localized contamination that would bias the reference data high.	
HC-2014-005	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • It appears that COPC concentrations in sediments for the entire lower KIH (below Belle Island) were used to compare the impacted areas to the reference area. We do not agree with this approach. For most COPCs, the impacted area in the lower KIH is localized primarily to the western portion of the	Category 2 - We agree with the comment, and have proposed to develop management areas that integrate sediment bed zones with similar contamination profiles. We would like to discuss our approach with Expert Support to confirm that the divisions of the impacted area are of an appropriate scale.	Satisfactory response. HC is available to discuss/review the approach at custodians' request.

	lower harbour, while the eastern portion of the lower harbour appears to be relatively unaffected by the sources along the western shore. For each COPC, only data from the impacted sediments should be used to compare impacted areas with the reference area. For example, based on information provided on Map 11-10, arsenic concentrations in sediments exceeding the ISQG appear to be limited to the western portion of the shoreline, extending between 200 m and 400 m offshore (an area that may occupy only approximately one third of the lower KIH). Arsenic concentrations in sediments exceeding the PEL are limited to a much smaller area along the central portion of the shoreline of the lower KIH. Map 11-10 clearly shows a distinct area of sediments impacted by arsenic and data from areas that are not impacted should not be included in the comparison between the impacted portion of the lower KIH with data from the reference area.		
HC-2014-006	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • It is not clear where fish tissue reference data were collected and sufficient rationale was not provided to support the selection of the reference location. In particular, it was not clear whether the home range of fish from the reference area	Category 1b - The location of both exposed and reference tissue collections have relevance to the risk refinement, as we will be linking tissue collections to areas of KIH. RMC-ESG has provided sufficient information of the location of fish samples to make these assignments. Additional details will be provided in the	Satisfactory response. No further comment.

	could include the KIH or whether there are potential sources of COPCs in the reference area. The Ontario Ministry of Environment (OMOE) Sport Fish Contaminant Monitoring Program could be contacted for further guidance. It may also be useful to determine whether OMOE considered metals other than mercury and chromium when they established the fish consumption advisories for the KIH.	risk refinement deliverable.	
HC-2014-007	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • We could not find details regarding the statistical analyses used to compare data from KIH to the reference area. Therefore, we could not check the approach and interpretation.	Category 1a - The statistical comparisons will be revised based on the division of water lots into management zones, and through exclusion of anomalous reference concentrations, both per previosu comments for Expert Support. Therefore, the details of what was done in the RMC-ESG deliverables will no longer be applicable.	Satisfactory response. No further comment.
HC-2014-008	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • Tables in Section B.I of the HHRA include Ontario Ministry of Environment (OMOE) sediment quality standards but not CCME sediment quality guidelines. Given that the KIH is under federal jurisdiction, the CCME sediment quality guidelines should also be considered for screening sediments, unless agreements between Federal and	Category 1b - The work conducted by Golder for Parks Canada and Transport Canada has already considered CCME sediment quality guidelines (where applicable) and has also considered guidelines from other jurisdictions. The risk refinement report will continue with this approach.	Please ensure this clarification is included in the report. Also please see response HC-2014-003.

	Provincial governments are in place that would warrant the use of OMOE sediment quality standards.		
HC-2014-009	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • The tissue screening value of 0.5 mg/kg for mercury cited in Table IV-9 was developed by Health Canada for retail fish and, in some cases, may not be an appropriate value for screening sport fish tissue as consumption patterns for sport fish may differ than those that were assumed for retail fish for the purposes of developing the retail fish screening value. The OMOE consumption guidelines listed in Table IV-9 appear to be from the 2009-2010 Guide to Eating Sport Fish and would likely represent a more appropriate screening value for tissue concentrations in sport fish, provided the assumptions regarding sport fish consumption used to derive the values are reasonably representative of consumption patterns expected at the KIH.	Category 1b - This information will be considered in the risk refinement.	Satisfactory response. No further comment.
HC-2014-010	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • Please note that the FDR/HC guidelines for arsenic and lead in fish protein cited in Table IV-9 apply to powdered fish protein and do not apply	Category 2 - We agree with the comment and propose to reassess the technical basis for screening of arsenic and lead through dietary consumption.	Satisfactory response. No further comment.

	point sources). It appears that the FDR/HC guidelines were used to screen out arsenic in fish tissue as the reference data could not be used for screening, although this was not explicitly stated. Arsenic concentrations in all of the reference samples were below the detection limit but the detection limit for the reference samples exceeded the maximum concentration measured in fish tissue from the study area. Further rationale should be provided for screening out arsenic in fish tissue, including justification for the use of the FDR/HC guidelines.		
HC-2014-011	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • Based on correspondence between HC and OMOE between June 24 and 26, 2014 the fish consumption advisories for the KIH are based on PCBs, mercury and chromium. It appears that mercury and chromium have been excluded as a COPC in fish tissue based on a comparison of site data with reference data. At a minimum, it should be acknowledged that OMOE has established fish consumption advisories in the KIH based in part on mercury and chromium in fish tissue.	Category 2 - Agree with comment; the basis for consumption advisories will be discussed in the risk refinement report, and implications for screening of pathways and substances considered.	Satisfactory response. No further comment.
HC-2014-012	[Chapter IV - Selecting and Screening	Category 2 - Agree with comment; the	Satisfactory response. No further

	directly to fish tissue. According to the Food and Drug Regulation, fish protein "(a) shall be the food prepared by (i) extracting water, fat and other soluble components through the use of isopropyl alcohol from fresh whole edible fish of the order Clupeiformes, families Clupeidae and Osmeridae and the order Gadiformes, family Gadidae, or from trimmings resulting from the filleting of such fish when eviscerated, and (ii) drying and grinding the protein concentrate resulting from the operation described in subparagraph (i); (b) may contain a pH adjusting agent; and (c) shall not contain (i) less than 75 per cent protein, which protein shall be at least equivalent to casein in protein quality, as determined by official method FO-1, Determination of Protein Rating, October 15, 1981." Sufficient rationale is not provided to justify application of these guidelines for screening fish tissue concentrations. We note that lead in fish tissue was not retained for further evaluation as the concentrations in the KIH were not significantly different from those in the reference area. Therefore, use of these screening values would not impact the overall finding for lead (provided that reference samples have not been impacted by the sources in the lower KIH or other		

	Contaminants of Potential Concern (COPCs)] • The text states in several locations that there is strong evidence that chromium from sediment is bioaccumulating into aquatic organisms. Also, as noted above, the fish consumption advisory for the KIH is based in part on chromium levels in fish tissue. The maximum and 95% UCLM for chromium in tissue from the study area are more than double those in the reference area. However, chromium in fish tissue from the reference area was found to be not statistically different from that in the study area. Therefore, chromium was not retained as a COPC in fish tissue. Parks Canada and Transport Canada may wish to confirm the validity of the reference samples and the statistical analyses given that Cr is shown to be bioaccumulating. Also, in any future evaluations of health risk associated with consumption of impacted fish in the lower KIH, it should be acknowledged that OMOE has established fish consumption advisories in the KIH based in part on chromium in fish tissue.	basis for consumption advisories will be discussed in the risk refinement report, and implications for screening of pathways and substances considered.	comment.
HC-2014-013	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • Based on information in the OMOE (2010) report Cataraqui River	Category 1b - See response DFO-2014-005; the risk refinement will exclude data for locations within the dredge footprint that were collected prior to dredging	Satisfactory response to HC June 27, 2014 comment. Older data may also not reflect

	Project Track-Down: Follow-up Study on Success of Remediation Efforts in the Cataraqui River 2006, it appears that sediments adjacent to Emma Martin Park were dredged in late-2004. However, based on information in Table II-1, it appears that eight of the twelve sediment sampling programs used to map the spatial extent of COPCs were completed prior to 2004. The report does not mention the dredging program off Emma Martin Park and it is not clear whether data that were collected from the dredged area prior to dredging were included in the risk assessment. It is recommended that the database be re-evaluated to confirm that data included in the risk assessment represent post-dredging conditions and that data from sediments that were removed from the KIH were not included.	program off Emma Martin Park.	current conditions, given that sediment are subject to disturbance, movement and resuspension and that chemicals are subject to environmental degradation, and may prevent the site assessor from drawing appropriate conclusions. HC recommends to assess the reliability of site data used. A rationale should be provided to explain which data is considered relevant or why older data is still relevant.
HC-2014-014	[Chapter IV - Defining Exposure Point Concentrations] • Given the substantial amount of sediment data available for the KIH, we agree with using a statistic other than the maximum measured concentration to represent the exposure point concentration. However, we do not agree with the use of 95% UCLM for the entire inner harbour to represent the exposure point concentrations for human receptors or to screen out COPCs. Based on the	Category 2 - Golder agrees with the general point being made, and proposes to address the issue through use of management zones rather than through calculation of the 95% UCLM for the entire contaminated zone. The objective will not be to identify small scale "hotspots" but rather to identify areas that may be expected to integrate exposures differently from other zones. We would like to liaise with Expert Support to	Satisfactory response. No further comment. HC is available to discuss/review the approach at custodians' request.

	information provided in Maps II-6 through 11-16, it appears that there are hot spots or localized areas of higher concentrations for each of the COPCs (typically along the western shored) and for most COPCs it appears that at least half of the KIH (typically the east half) has relatively low concentrations (i.e., below the PEL and in some cases below the ISQG). Given the large area represented by the KIH, individuals would not be expected to be exposed to all sediments in the entire harbour equally. Instead, it would be expected that an individual would spend time within a smaller area within the harbour. Different individuals may spend time in different areas of the harbour and, with the exception of boaters, activities would be expected to be , focused at or near the shoreline. Given that the hot spots for most COPCs appear to be localized at and/or near the shoreline on the western side of the KIH, some people may be expected to be exposed to average COPC concentrations that are substantially higher than the" 95% UCLM for the entire harbour. For example, based on the contaminant concentration profiles in Maps II-6 and 11-12, the highest concentrations of antimony and chromium appear to be found primarily in the area south of Cataraqui Park, east of Orchard	confirm that the number of zones identified is appropriate for the assessment of human and wildlife health risks; these pathways will combine exposure over multiple areas, through their own foraging behaviour and through the movements of prey.	

	Street Marsh. This area also has lead concentrations in sediment that are substantially higher than most of the rest of the harbour (see Map II-7). If a receptor were to visit this area, the average sediment concentrations of antimony, chromium and lead to which they would be exposed would be substantially higher than the 95% UCLM for the entire harbour. The human health risk estimates based on the 95% UCLM for the entire harbour should not be considered reliable estimates of potential risks for individual receptors accessing the shoreline at various locations along the western shore of KIH. Health risks associated with exposure to chromium, copper, zinc, DDT, chlordane, naphthalene and pyrene were considered acceptable based on exposure to the 95% UCLM for the entire harbour. However, for receptors who visit areas with localized higher concentrations of COPCs in sediments (e.g., the area adjacent to orchard street marsh and Belle Park and the area between the marinas and Emma Martin Park) potential health risks may be substantially higher than predicted as these receptors would be exposed to an average sediment concentration that is substantially higher than the 95% ULCM for the entire harbour.		

HC-2014-015	[Chapter IV - Defining Exposure Point Concentrations] • Special management areas: Section F of the HHRA introduces the concept of special management areas (SMAs), which appear to be areas with localized higher concentrations of a particular COPC. Special management areas appear to be defined only for arsenic, mercury, PCBs and PAHs based on considerations related to human health and for chromium and PCBs based on considerations related to ecological health. The human health risk assessment presents risk estimates for arsenic and mercury within the SMA and for arsenic and mercury outside the SMA. The exposure point concentrations defined for the SMAs may provide a more realistic estimate of the concentrations that people who visit this area may be exposed to (depending on how they were defined relative to the contaminant distribution and relative to the areas that people may frequent) resulting in more realistic risk estimates for these receptors. There appears to be an area of localized elevated mercury concentrations in sediments outside of the SMA in the vicinity of the marinas. The use of the 95% ULCM mercury concentrations in sediments for the remainder of the KIH outside of the SMA to estimate risk for human receptors would not account for this	Category 2 - See response HC-2014-014 above. We were also confused by the concept of special management areas (SMAs) because there was not a clear articulation of why SMAs were developed for some pathways and substances but not for others. As before, we would like to confirm the scale of management areas that best strikes a compromise between the need to average exposures over areas (for realism and relevance to plausible exposure scenarios) and the need to acknowlege larger contiguous areas of sediment that have a different contamination profile than other parts of the harbour.	Satisfactory response. No further comment.

	hot spot where people may be exposed to substantially higher concentrations throughout the area. If people are expected to be exposed to COPCs in sediments in areas with locally elevated concentrations, health risks should be evaluated for these areas using an exposure point concentration that is representative of the area where an individual may be exposed.		
HC-2014-016	[Chapter IV - Defining Exposure Point Concentrations] • Table IV-22 provides HQ values for arsenic, inorganic mercury and lead that have been adjusted for background exposure, such that a threshold of 1 would be more appropriate than a threshold of 0.2 for defining potentially unacceptable risk. The HQ values reported for the area outside the SMA would only be an appropriate representation of human exposure outside the SMA if the sediment concentrations outside the SMA are relatively uniform throughout the entire KIH and there are no significant hot spots or areas where COPCs are locally elevated. As noted above, there appears to be at least one significant hot spot of mercury in sediments outside of the SMA in the vicinity of the marinas. Therefore, the HQ values reported for mercury in sediments outside the SMA (which are based on a 95% UCLM for the entire harbour outside	Category 1b - This concern should be addressed through the specification of new management areas, and/or through adjustment of the screening HQ to 0.2 for As, Hg and Pb.	Satisfactory comment. No further comment.

	the SMA) may not accurately reflect potential risks for people who would be exposed to mercury in sediments in the vicinity of the marinas. Likewise, the lead HQ for the entire KIH would not be representative of human exposure in areas with locally elevated concentrations along the shoreline.		
HC-2014-017	[Chapter IV - Defining Exposure Point Concentrations] • Two samples from the outlet of the Orchard Marsh at depths of 17.5 cm and 52.5 cm with antimony concentrations substantially higher than most of the rest of the KIH were removed from the data set and human health risks were re-calculated based on the 95% UCLM of the remainder of the data set for the KIH. No rationale was provided for removing these two samples. If it is presumed that people would not be exposed to sediment at these depths and if surficial sediments in these areas have been characterized, it may be reasonable to remove these samples from the data set. However, as noted previously, the 95% UCLM for the entire KIH may underestimate risks to people who would access the shoreline in the vicinity of Orchard Street Marsh, Cataraqui Park and the former lead smelter as there appears to still be sediments with elevated antimony	Category 1b - Samples collected at depth will be removed from the database used to assess present-day risks. However, contamination at depth will be considered in the future pending the outcome of the risk refinement. The risk refinement will include rationale for screening on sediment chemistry data in the vertical dimension.	Satisfactory response. No further comment.

	concentrations well above the CCME soil standard in this area even when the two samples at depth are excluded.		
HC-2014-018	[Chapter IV - Defining Exposure Point Concentrations] • Pg II-6 (Chapter IV): Samples with elevated PAH concentrations at depths ranging from 31 to 123 cm collected from the Anglin Bay area with "extremely high concentrations of PAHs" (total PAHs 18-20,600 mg/kg) were excluded from the risk assessment. The rationale provided was as follows: "Anglin Bay is an area not expected to encounter much use in terms of wading or even swimming and thus these depth samples are unlikely to be available to pose risk to humans." However, text on page II-2 (Chapter IV) states that the docks located near the LaSalle Causeway and Anglin Bay are often used for swimming and other water-related recreational activities. We agree that exposure to the deeper sediments with elevated PAH concentrations is unlikely provided they are not exposed due to disturbance of surficial sediments (e.g., due to prop wash). Further rationale for excluding these samples is recommended, including confirmation that the area of contamination has been delineated (including data for the surficial sediments in the area), the	Category 3 - See response HC-2014-017 above. The clear distinction between present-day risks based on near-surface chemistry, versus potential risk scenarios through sediment disturbance, needs to be made. In the case of sediment PAHs, the very high concentrations of PAHs in some samples (i.e., hazardous waste) also warrant consideration in the remedial options analysis.	Satisfactory response. No further comment.

	location of the sediments relative to areas where people are expected to swim or wade and confirmation that the surficial sediments overlying the sediments with "extremely high PAHs" are not expected to be disturbed. If these sediments are excluded from the risk assessment, they may still need to be risk managed to ensure that they do not become exposed/uncovered (e.g., if overlying sediment were to be dredged, these deeper sediments with substantially higher PAH concentrations could become exposed).		
HC-2014-019	[Chapter IV - Defining Exposure Point Concentrations] • As noted previously by Health Canada in comments provided in a letter dated June 18, 2010 and by Golder Associates in their technical memorandum dated March 31, 2014, dioxin-like PCBs are not explicitly addressed in the risk assessment. The report does not note whether dioxin-like PCB congeners have been analyzed in sediments in the lower KIH. OMOE (2010) report congener specific PCB concentrations in their report Cataraqui River Project Track-Down: Follow-up Study on Success of Remediation Efforts in the Cataraqui River 2006. If sufficient data are available, they should be considered in the risk assessment. If the data are not available,	Category 2 - We would like to discuss this issue with Expert Support, given that previous feedback has been that Health Canada does not evaluation dioxin-like PCBs as carcinogens, but rather as non-carcinogens using the hazard quotient method. However, methods for assessing dioxin-like PCBs quantitatively is possible for wildlife risk assessment (e.g., application of CCME tissue guidelines for TEQs).	It is recommended that the HC-2014-019 comment be taken into account in the risk assessment. HC is available to discuss/review the approach at custodians' request. As per Health Canada Part II-TRVs (2010), dioxin-like PCBs are to be evaluated with dioxins as non-carcinogens, using appropriate toxic equivalence factors (TEFs) (see Table 8 of HC Part I-PQRA (2012)) and HC tolerable daily intake for polychlorinated dibenzo-*p*-dioxins/ polychlorinated dibenzofurans (PCDDs/PCDFs). Based on the literature available at

	the potential implications of this data gap should be considered and discussed in the risk assessment. If any future sediment sampling is planned for the lower KIH, consideration should be given to analyzing a subset of samples for dioxin-like PCB congeners, if warranted.		that time (2010), a threshold was expected for the carcinogenic effects of dioxins and dioxin-like PCBs, and a developmental endpoint was identified as a more sensitive endpoint than carcinogenicity (i.e. a higher dose is required to induce cancer than to induce developmental effects in the offspring). Therefore the TRV for dioxins, which is based on developmental effects, would also be protective against carcinogenic effects and appropriate for assessment of typical, low dose exposure. However, recently, the International Agency for Research on Cancer (IARC) reassessed the carcinogenicity of dioxin-like PCBs and dioxins; these substances were upgraded to Group I, known carcinogens. Therefore, recent alternate TRVs (e.g. slope factors) from another regulatory agency, if available, could be used in addition to the HC TRVs to also address the carcinogenic effects of dioxins and dioxin-like PCBs, with appropriate scientific rationale.

HC-2014-020	[Chapter IV - Defining Exposure Point Concentrations] • Hg in fish: Map III-9 seems to show the highest concentrations of Hg in juvenile yellow perch in the area adjacent to the Kingston rowing club, which is within the area of highest contaminant concentrations. Is it possible that fish within the areas of the harbour with highest Hg concentrations in sediments may have higher concentrations of Hg in tissue? If this is the case, and if it is possible that some people may primarily fish within this area, the use of the 95% UCLM for all fish tissue from the inner harbour may underestimate risks for some receptors.	Category 2 - This issue should be discussed in the context of defining management areas. There are several interrelated issues including the degree to which fish collections may reflect localized contamination, the degree to which the fish foraging patterns would smooth out such differences over time, and whether human use patterns would smooth out concentration differences.	Satisfactory response. No further comment.
HC-2014-021	[Chapter IV - Defining Exposure Point Concentrations] • Fish data were not separated by species. If some people may have a preference for a particular species they may consume only one species rather than an average of all species. The report does not include summary statistics for individual species. Therefore, it is not clear whether contaminant concentrations in tissue of any one species may be significantly higher than others. The potential for higher risks associated with selective consumption of the species with the highest concentrations (rather than equal consumption of all species) may	Category 2 - It is common in HHRAs to make simplifying assumptions regarding the dietary preferences of recreational fishers, either through use of an indicator representative species (or combination of species), or through the assumption that measured concentrations in all harvested fish are representative of typical exposure. In this site context, it difficult to define any specific scenario as being optimal. We would like to liaise with Expert Support for guidance on how to incorporate the variations in fish concentration data without making unrealistic or overly conservative assumptions for species	No further comment. HC is available to discuss/review the approach at custodians' request.

	need to be explored if it has not already been considered.	preference.	
HC-2014-022	[Chapter IV - Surface Water Data] • Maps showing surface water sampling locations are not provided in the report (references are provided to other reports where they can be found). Therefore, we could not determine where samples were collected or the surficial sampling program covered sufficient and appropriate areas of the KIH.	Category 4 or 5 - Comment relates to RMC-ESG deliverable; this remains as an uncertainty.	To facilitate peer review and verification of assumptions, maps depicting all surface water sampling locations should be included in the upcoming risk assessment deliverables (or should be provided to ES) as it is helpful in demonstrating or determining if the sampling plan has been adequate to reflect the distribution of chemicals across the site. It could also be important for health risk communication purposes to have a "stand alone" document that includes all pertinent data, assumptions, maps, etc.
HC-2014-023	[Chapter IV - Surface Water Data] • Surface water data is presented only for a subset of the inorganic COPCs (Table IV-8). In particular, data for mercury, antimony or arsenic were not presented in Table IV-8 and it is not clear whether they were analyzed in surface water. If they were analyzed, it is not clear why they are not included in Table IV-8 and the interpretation of surface water data. If they were not analyzed, it is not clear why.	Category 5 - We cannot address this issue without provision of surface water chemistry data from RMC-ESG (assuming that such data exist). Although it is likely that other risk pathways (sediment and dietary exposure) are more important for these parameters, the lack of clear water column screening remains as an uncertainty.	It is recommended that all relevant data, assumptions, etc. regarding surface water be provided, to facilitate peer review and verification of assumptions. It could also be important for health risk communication purposes to have a "stand alone" document that includes all pertinent data, assumptions, etc.

HC-2014-024	[Chapter IV - Surface Water Data] • Surface water samples were analyzed for both total and dissolved metals. The maximum total metals concentrations for lead, zinc and chromium were higher than Ontario Drinking Water standards and Canadian drinking water quality guidelines (CDWAG) (lead and chromium exceeded the Canadian drinking water quality guidelines by several orders of magnitude); however, maximum dissolved concentrations were below both the Ontario standards and the CDWAG. The report indicates that because the dissolved phase constituents were below guidelines/standards and because exposure to suspended solids is evaluated separately, exposure to COPCs in surface water is not considered as a pathway. It is reasonable to evaluate human exposure to suspended sediments separately as people would be expected to disturb the sediments while wading/swimming in shallow water and be exposed to a higher suspended sediment concentration than that measured in surface water samples (which are typically collected in a manner that would minimize the amount of suspended solids in the sample). However, it may also be useful to evaluate risks associated with consumption of surface water during recreation based on	Category 2 - We agree that comparisons of water concentration data should be made to Canadian drinking water quality guidelines using the total concentrations (not dissolved). We will reassess the screening procedure on this basis. With respect to the the calculation of dose in the HHRA, there are multiple choices available for breaking down the total xposure (e.g., suspended sediment combined with water, or separated out as a distinct exposure medium). What is most important is that the parameters assigned to these media (ingestion rates, and concentration estimates) be reasonably reflective of the receptor scenario of interest. We would like to consult with Health Canada on some of the ingestion rates, including incidental sediment ingestion and water ingestion, as the tabulated values in Table IV-13 appear over-conservative.	Satisfactory response. No further comment. At custodians' request, HC could be consulted about ingestion rates.

	total COPC concentrations in surface water as a check for comparison with the estimates based on predicted exposure to suspended sediments.		
HC-2014-025	[Chapter IV - Surface Water Data] • It is not clear whether the reference data for surface water are for total or dissolved constituents. Therefore, it is not clear how the data from KIH compare with the reference data. With the exception of zinc, the maximum concentrations of dissolved data are very similar to those for the reference site for each of the parameters shown on Table IV-8.	Category 5 - Will be addressed in upcoming risk refinement, provided that RMC-ESG can provide assistance in determining units for these data.	Satisfactory response. No further comment.
HC-2014-026	[Chapter IV - Exposure Media] • The report states that there are no beaches or formal bathing areas in the KIH and that people would only be exposed to sediments that are submerged under water. Transport Canada and Parks Canada may wish to confirm that there are no beach-like areas within their water lots and that water level fluctuations do not occur that would expose the contaminated sediments resulting in exposure similar to that in the tidal flat or on a beach.	Category 3 - Requires liaison with Expert Support, and perhaps other parties. The distinction between permanently wetted sediments and those that may be exposed (dry) intermittently along the shoreline has implications for several HHRA parameters, particularly dermal absorption. One approach would be to discuss potential beach formation in the uncertainty assessment vis-à-vis future exposure scenarios and level of conservatism. Also can confirm with Parks Canada and Transport Canada what is known about current human use/access or future scenarios. It appears that dry contact with sediments was not included in the	If beach-like conditions can or could exist, HC recommends that potential health risks associated with these specific areas be evaluated, if possible (not just discussed in the uncertainty section).

		RMC-ESG assessment (whereas wet contact with submerged sediments was); our approach for the risk refinement will be to confirm the assumptions, determine if beach like conditions can or could exist, and discuss implications in uncertainty assessment.	
HC-2014-027	[Chapter IV - Exposure Media] • In their response to Health Canada comments on a previous version of Chapter IV (dated November 5, 2010 and included in Appendix M of the report) Environmental Sciences Group (ESG) notes in comment 16 that "potential direct exposures to bulk dry sediments (such as exposures at a beach) are included in the risk assessment". As noted above, this type of exposure was not included in the risk assessment as there are reportedly no areas of exposed sediments in the lower KIH.	Category 1b - Agree that statement is confusing; will confirm if they are or are not included and explain.	See HC-2014-026 response.
HC-2014-028	[Chapter IV - Exposure Duration and Amortization] • The exposure scenario evaluated is for a person visiting the KIH daily for the months of July and August (for a total of 61 days). It is not clear why receptors would not be expected to visit the site in June or September. Also, the assumption of daily exposure during warmer months may need to be revisited. It appears that there may be residential areas	Category 2 - We will recommend adjusting the amortization for non-carcinogens (longer than 2 months) but also reducing the frequency of site use (less than daily) – the overall risk is a balance between these considerations. Specification of a single scenario that is considered appropriately protective of a population is challenging, particularly when usage patterns may change with foreshore redevelopment.	Satisfactory response. No further comment.

	in close proximity to the western shore of the KIH and residential developments are reportedly planned for the undeveloped portions of the western shore. However, the current physical setting does not reportedly include beaches or other areas that would encourage frequent, repeated wading and swimming.		
HC-2014-029	[Chapter IV - Exposure Duration and Amortization] • Exposure Amortization: Direct contact exposure was assumed to occur daily for 61 days during July and August. This exposure period was amortized over the entire year to estimate exposure. Please note that exposure amortization should be completed on a chemical specific basis with sufficient rationale. In this case, we recommend that the exposure for non-carcinogens be amortized only over the period during which exposure may occur (in this case July and August), unless rationale can be provided for an alternate approach. As noted in the previous comment, the assumption of daily exposure during the entire exposure period could be revisited to evaluate whether it would be reasonable or overly conservative.	Category 2 - See response HC-2014-028 above – similarly, an assumption of more months per year, but with fewer visits per month may be appropriate.	Satisfactory response. No further comment.
HC-2014-030	[Chapter IV - Exposure Duration and Amortization] • Fish consumption rates	Category 2 - Similar to responses HC-2014-028 and -029 above, it is challenging	The significance of the exposure amortization inherent in developing

	were developed based on information from the OMOE (2006) document 2003 Guide to Eating Ontario Sport Fish Questionnaire which is relevant for fish consumption in the Great Lakes. The meal size of 236 g/meal and the consumption frequency of 39 meals/year were used to derive an average daily consumption rate of 24.9 g/day. This results in a significant amortization of exposure to COPCs in fish tissue. Also, it is not clear whether respondents of the OMOE Sport Fish Questionnaire consumed the 39 meals throughout the year (e.g., some fish were frozen for future consumption) or whether consumption was concentrated primarily within a limited fishing season. We recommend that exposure amortization be completed on a chemical and site-specific basis with supporting scientific rationale. The significance of the exposure amortization inherent in developing the average daily consumption rate should be discussed in the risk assessment. If further work is to be done to refine risk estimates for the lower KIH, we recommend contacting OMOE for further guidance on evaluating exposure to COPCs through consumption of impacted sport fish.	to provide exposure amortization "on a chemical and site-specific basis with supporting scientific rationale." The scenario provided is simplified given the lack of site-speciifc information, and it is likely that a scenario of more months per year (i.e., longer fishing and consumption season) is reasonable. However, this begs the question of whether the number of meals per month would also need to be adjusted to compensate. Given that previous advice from Health Canada on earlier RMC-ESG documentation resulted in reduced ingestion rates, it is not clear whether Health Canada is concerned about the specific details of rationale/methods, or with the final tissue ingestion rate, or both.	the average daily consumption rate should be discussed in the risk assessment. This could include a discussion of the uncertainty related to how dose averaging conducted might impact on the risk estimation, assuming various potential fish consumption scenarios. Additionally, OMOECC could be contacted for their guidance on evaluating exposure to COPCs through consumption of impacted sport fish in the Kingston Inner Harbour (since their data forms the basis of the fish consumption rates developed).
HC-2014-031	[Chapter IV - Exposure Parameters] • Dermal Adherence: Dermal adherence	Category 2 - We agree that the dermal adherence factors require careful	No further comment.

	factors for sediments reported by Shoaf et al (2005) were used to evaluate exposure to bedded sediments submerged under water and soil dermal adherence factors from Health Canada PQRA Part I (2012) were used to evaluate exposure to suspended sediments. Please note that there is significant uncertainty associated with the use of the Shoaf et al (2005) dermal adherence factors to estimate dermal exposure to bedded sediments submerged under water. The Shoaf et al (2005) values were estimated based on a study of children playing in a tidal flat comprised of primarily medium sand with an organic carbon content on the order of 1% to 2%. The children in the study were in contact with both submerged (including bedded and suspended) and exposed sediment and the bulk of the adhered sediments is presumably from contact with the exposed sediments rather than the submerged sediments. The exposure scenario evaluated for the KIH involves people playing in shallow water where they are exposed only to submerged (bedded and suspended) sediments that are reported to be comprised of primarily silt and clay with a relatively high organic carbon content (greater than 10% in some locations). If people were expected to be in contact with exposed sediments (i.e., not	consideration in recognition of the data sets available and their relevance to the plausible exposure scenarios for KIH. We have summaries of dermal adherence factors, including data from Shoaf, Kissel, and other authors, but the correspondence to a submerged exposure scenario is weak, even before substrate differences are taken into account. We agree with Expert Support that the existing dermal adherence factors likely overestimate adherence for both bedded and suspended sediments in water, but require guidance for making more realistic estimates.	

	submerged under water) along the shoreline of KIH, the adherence values reported by Shoaf et al (2005) would likely underestimate exposure due to the nature of the sediments (very fine grained with high organic carbon content). However, there are reportedly no exposed sediments along the shoreline and the risk assessment evaluates exposure only to bedded sediments submerged under water and suspended sediments in surface water. Submerged and suspended sediment would not be expected to adhere to the same degree as exposed sediment and a significant portion of submerged and suspended sediment would be expected to wash off as people exit the water. Overall, both the Shoaf et al (2005) dermal adherence factors and the Health Canada (2012) soil dermal adherence factors are expected to overestimate dermal adherence for people playing in the water in KIH. Given that the dermal pathway is a significant contributor and/or driver of risk for most COPCs, consideration should be given to refining the dermal exposure estimates. We are not aware of any published dermal adherence factors relevant to a scenario where people are exposed only to sediments submerged under or suspended in water. Careful consideration should be given to selecting		

	adherence factors for this scenario. Also, if dermal exposure is re-evaluated, one potential approach would be to use one set of dermal adherence factors to estimate combined adherence of both bedded sediments submerged under water and suspended sediments in water, rather than considering them separately and adding the exposures. This may be reasonable since exposure to bedded and suspended sediments in water would generally occur simultaneously for receptors playing in shallow water along the shoreline and the existing dermal adherence factors likely overestimate adherence for both bedded and suspended sediments in water.		
HC-2014-032	[Chapter IV - Exposure Parameters] • No rationale was provided for the use of the Health Canada (2012) soil dermal adherence factor for evaluating exposure to suspended sediments. Also, it is not clear why the Shoaf et al (2005) values were used for hands and feet but the soil values from the PQRA were used for arms and legs as Shoaf et al (2005) report values for arms and for legs. In any subsequent analysis of dermal exposure, sufficient rationale should be provided for the selected dermal adherence factors.	Category 1b - See response to HC-2014-031, above. Once we sort out the exposure factors above, the specific concerns raised in this comment can be addressed, and rationale provided.	Satisfactory response. No further comment.
HC-2014-033	[Chapter IV - Exposure Parameters] •	Category 1b- In the absence of an official	Satisfactory response, however,

	for publication. Rates were developed for hand-to-mouth contact with exposed sediments that are notsubmerged under water (e.g., intertidal sediments or beach sediments) and for incidental ingestion of suspended sediments in surface water. The proposed rates are on the order of 72 mg/hour and 20 mg/hour for children and adults, respectively for incidental ingestion of exposed sediments due to hand-to-mouth contact and 8 mg/hour for all receptors for incidental ingestion of suspended sediments during in-water recreational activities. Based on the exposure time of 73 minutes/day selected for swimming/shoreline play in KIH for toddlers and adults, these rates would correspond to daily rates of 88 mg/day for toddlers and 24 mg/day for adults for incidental ingestion of exposed sediment via direct contact and 10 mg/day for ingestion of suspended sediments. The total exposure for people visiting the KIH via sediment ingestion is likely highly overestimated as ingestion of bedded sediments submerged under water is expected to be insignificant. If sediment ingestion rates were re-evaluated based only on ingestion of suspended sediments, it is recommended that the values proposed by Wilson and Meridian be considered, rather than the lower suspended sediment		

	Sediment Ingestion rates: The exposure scenario evaluated for the KIH involves a receptor wading and swimming in the near-shore water, where they may be exposed to COPCs in sediments submerged under water, including suspended sediments and bedded sediments. Table IV-13 cites sediment ingestion rates of 200 mg/day for toddlers and 100 mg/day for adults. At the time that the original risk assessment was completed in 2010, these values were recommended by Health Canada as a conservative approximation of sediment ingestion rates for people in contact with exposed sediments (i.e., not submerged under water). Given that people are not expected to be in contact with exposed sediments (e.g., beach sediments), incidental ingestión of sediment would likely occur primarily via incidental ingestion of suspended sediment in surface water while playing in the water. Incidental ingestion of bedded sediments is not expected to be significant. Therefore, it appears that the sediment ingestion rates of 100 mg/day for adults and 200 mg/day for children would not be relevant for the site. Please note that Wilson and Meridian (2011 and 2013) developed sediment ingestion rates for Health Canada under contract and a manuscript is currently being developed	Health Canada procedure, we agree that sediment ingestion rates from Wilson and Meridian (2011 and 2013) provide an improved basis for evaluating this pathway, and should replace the over-conservative estimates originally assigned. We propose to use these recent estimates, acknowledging that the hourly estimates require assumptions regarding the number of hours per day spent recreating for each receptor. We propose to apply estimates of hours of exposure per day for toddlers and children (2 hours/day) and teens/adults (4 hours/day).	where possible, assumptions associated with exposure duration and frequency should be documented/justified. Please note that assumptions based on survey of time-activity patterns generally take precedence over assumptions based on regulatory guidance, literature or professional judgment.

	rates (1.5 mg/day) used in the HHRA.		
HC-2014-034	[Chapter IV - Toxicity Reference Values] • The source of the chlordane TRV is not clear.	Category 1a - RMC report Table IV-16 references an oral tolerable daily intake (TDI) of 3.3 x 10^{-5} mg/kg-day for chlordane, and Appendix J (Section C – Chlordane) indicates that this value was obtained from OMOE (2011). OMOE (2011) indicates the TRV is a non-cancer child-specific reference dose (chRD) derived by the California Environmental Protection Agency (CalEPA 2005). The chRD is based on a 1994 study where changes in sex-steroid mediated behaviours were observed in male and female rats following pre- and post-natal exposure to chlordane (Cassidy et al. [1994], as cited in CalEPA 2005). A chlordane dosage of 0.1 mg/kg-day was found to disrupt sex hormone mediated behaviours and was identified as the lowest observed adverse effect level (LOAEL). CalEPA applied a total uncertainty factor of 3,000 (10 for interspecies variability, 10 for human variability and 10 to extrapolate from a LOAEL to a NOAEL, and 3 to account for database deficiencies) to the LOAEL to calculate the cHRD. CalEPA (California Environmental Protection Agency). 2005. Development of Health Criteria for School Site Risk Assessment Pursuant to Health and Safety Code Section 901(g): Child-Specific	Satisfactory response. No further comment.

		Reference Doses (chRDs) for School Site Risk Assessment - Cadmium, Chlordane, Heptachlor, Heptachlor Epoxide, Methoxychlor, and Nickel. Final Report, December 2005. Integrated Risk Assessment Branch, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. Available at http://oehha.ca.gov/public_info/public/kids/pdf/FinalSchoolReport121205.pdf. OMOE (Ontario Ministry of the Environment). 2011. Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Sites in Ontario. Prepared by Standards Development Branch, OMOE. April 15, 2011. Available at https://www.ontario.ca/environment-and-energy/rationale-development-soil-and-ground-water-standards-use-contaminated-sites.	
HC-2014-035	[Chapter IV - Toxicity Reference Values] • The Contaminated Sites Division (CSD) of Health Canada currently does not endorse a toxicity reference value (TRV) for lead for use in human health risk assessments at contaminated sites. The previous value in Health Canada's guidance - a tolerable daily intake (TDI) of 3.6 µg/kg-day - is no longer recommended	Category 2 - We agree that, pending the review of the toxicology of lead by Health Canada, an alternate for lead should be drawn from another regulatory agency. We are proposing to use an alternative TRV based on a recent SNC-Lavalin assessment of lead toxicity to adults, infants, toddlers, and children. Their assessment resulted in a TRV based on WHO (2011) assessment,	Please note that TRVs developed by other jurisdictions, including values from the WHO JECFA (2011) and EFSA (2013), or in peer reviewed scientific literature may be acceptable with sufficient justification and supporting data. A brief summary of the key health concern(s) associated with

	for use within contaminated site risk assessments. We also no longer recommend the use of the OMOE TDI of 1.85 µg/kg-day. These TDIs were based on a value from JECFA/WHO, which has been withdrawn by JECFA as it was considered that the value was unlikely to be protective of human health (JECFA, 2010). Until the review of the toxicology of lead is completed by Health Canada, it is recommended that qualified risk assessment professionals identify a TRV for lead from another regulatory agency. Alternate TRVs, including values from the California OEHHA (2007; 2009) or JECFA, may be used in quantitative risk assessments at federal contaminated sites, with appropriate scientific rationale.	a conclusion consistent with the withdrawal of the WHO (2010) value by Health Canada.	exposure should be provided within the risk assessment report. The summary should discuss both cancer and non-cancer endpoints, and differentiate effects by exposure route (oral, dermal, inhalation), as appropriate.
HC-2014-036	[Chapter V - Need for Management Actions: Summary of the Main Outcomes from Chapters II, III and IV] • It is noted on page 1-2 that "the toxicity thresholds do not account for possible synergistic effects resulting from the complex mixture of contaminants in the APEC" and that the assessed risk may therefore be "greatly underestimated". The term "greatly" is not qualified with supporting text and although this statement on possible synergistic effects appears to be related to assessed ecological risk (i.e. to the brown bullhead	Category 4 - This comment, which we agree with, appears to relate to narrative that is specific to the RMC-ESG deliverable. However, the broader implications of the comment link to the degree of certainty we can have that remediation drivers have been appropriately identified. Given the challenges in evaluating interaction effects for both human health and ecological receptors, this issue is best dealt with in the uncertainty analysis..	The HC-2014-036 comment still stands for the RMC-ESG report or for the upcoming risk refinement report.

	fish), it undermines one of the report's major messages (i.e. that it is now time for management actions) since the management actions may not mitigate the currently unknown risks to receptors from chemical mixtures. Furthermore, there does not seem to be any initiative to assess possible synergistic effects of the complex chemical mixture on health risk to humans. Given the complexity of the chemical mixture, the challenges inherent to managing any assessed risk (likely a combination of management actions) and the goals of risk mitigation (i.e. to reduce risk to receptors), assessment of chemical mixtures or perhaps further consideration in an uncertainty analysis, may be considered.		
HC-2014-037	[Chapter V - The Framework for Addressing and Managing Contaminated Sites Under the Federal Contaminated Sites Action Plan] • There is a footnote on page II-1 that refers to "Section 6.1.1.2 of Treasury Board Guidelines" that not only does not provide a reference, but also selectively and incompletely quotes Treasury Board Policy. The lack of proper reference makes the content difficult to verify by the reader. The text is in fact a slightly refined (text omitted) exact quote of Section 6.1.12 (not	Category 4 - This comment is specific to the RMC-ESG report.	The HC-2014-037 comment still stands for the RMC-ESG report or for the upcoming risk assessment deliverables.

	6.1.1.2, which does not exist) of the Treasury Board (TB) Policy on Management of Real Property (effective November 11, 2006). The most notable omission is the word "federal" that should be present in the sentence, "Management activities (including remediation) must be undertaken to the extent required for current or intended federal use." The other omission from the TB Policy is "...or requirements that may be applicable abroad" in the sentence: "These activities must be guided by standards endorsed by the CCME or similar standards or requirements that may be applicable abroad." It is recommended that any inaccurate interpretations made in the report text as a result of the omissions be corrected.		
HC-2014-038	[Chapter V - The Framework for Addressing and Managing Contaminated Sites Under the Federal Contaminated Sites Action Plan] • On page II-2, it is noted that completion of the ASCS Pre-screening Checklist led to an automatic Class 1 designation for the site and that the worksheets were completed for "comparative purposes". It should be noted that current guidance specifies that "A site scored as Class 1 using only the pre-screening checklist will not be considered	Category 4 - Our scope does not include NCSCS or ASCS classification; however, our scoring at DQRA stage also identified a Class 1 designation.	The HC-2014-038 comment still stands for the RMC-ESG report or for the upcoming risk assessment deliverables.

	eligible for FCSAP R/RM funding without the completion of the remaining NCSCS or ASCS worksheets for eligibility review." Nevertheless, the full scoring completed by ESG ultimately did score the site as Class 1.		
HC-2014-039	[Chapter V - The Framework for Addressing and Managing Contaminated Sites Under the Federal Contaminated Sites Action Plan] • There does not seem to be any justification given on page 11-17 for the statement, "...it is unlikely that [combined sewer overflow] effluent contains high levels of contaminants such as Cr and PCBs..." i.e. there should be justification qualifying why this is unlikely.	Category 4 - This comment is specific to the RMC-ESG report.	The HC-2014-039 comment still stands for the RMC-ESG report or for the upcoming risk assessment deliverables.
HC-2014-040	[Chapter V - Analysis of Management Options] • On page III-6, the dredging management option is selected as the preferred remediation strategy in part due to its "likely effectiveness"; however, the statement is not supplemented by supporting documentation that demonstrates its effectiveness for the site in question. Furthermore, the statement on page III-7 that "dredging does not require long-term maintenance or post-remediation performance monitoring" can be misleading since performance	Category 4 - This comment is specific to the RMC-ESG report.	The HC-2014-040 comment still stands for the RMC-ESG report or for the upcoming risk assessment deliverables.

	effectiveness would need to be monitored and thus demonstrated, as is indicated in Table V-I, page II-7, Risk Management Principle #11.		
HC-2014-041	[Chapter V - Analysis of Management Options] • There is little discussion regarding prevention of recontamination of any dredged areas by adjacent contaminated sediments. Accordingly, the management options analysis should have identified mitigation measures to ensure/minimize the dredged areas becoming impacted by adjacent sediment. Furthermore, the analysis of management options only considers the management options in isolation of one another not taking into considerations innovative and integrated solutions. Management options may ultimately involve a combination of the various methods available (no action, institutional controls, monitored natural recovery, capping, dredging, etc.), since the site is complex in its contaminant profile and physical/chemical/biological processes and issues and goals are geographically unique.	Category 4 - This comment is specific to the RMC-ESG report.	The HC-2014-041 comment still stands for the RMC-ESG report or for the upcoming risk assessment deliverables.
HC-2014-042	[Chapter V - Sediment Management Goals for the KIH] • The spatially weighted average concentration (SWAC) methodology and, in particular, the procedure for calculating the area of the	Category 1b - In the risk refinement, exposure point estimates (and supporting statistics) with be provided for each management zone.	Satisfactory response. No further comment.

	harbour "requiring management" for each COC, are not explained in clear enough detail for the reader and there is a lack of supporting calculations. Also, the discussion regarding SWACs for various COCs seems out of place on page IV-11, as it appears in a section dedicated to deriving Sediment Quality Objectives (SeQOs) for PCBs.		
HC-2014-043	[Chapter V - Sediment Management Goals for the KIH] • The rationale for the choice of the boundaries of the PAH management zone lacks clarity. In fact, there doesn't seem to be a complete rationale justifying the footprint of the ultimately proposed management areas. Also, the ESG overall proposed management area excludes most of the area, i.e. in and around Anglin Bay, that Golder (2012) had previously identified as being the best candidate for active management based on evidence gathered by them to-date.	Category 1b - We agree with the comment. The boundaries for the PAH management zone may have been defined based on an acknowledgement that HQs could not be reduced to below one without identification of a large volume of sediment. The risk refinement will contain several changes to the exposure parameters that will influence HQs (on an area-specific basis).	Satisfactory response. No further comment.
HC-2014-044	[Chapter V - Sediment Management Goals for the KIH] • Given the spatial extent and levels of contamination in sediments (Maps II-6 to 11-16) adjacent to the SWAC zones shown in Maps V-I to V-8 (and the proposed PAH shoreline management area), it would appear likely that contaminant levels in dredged zones	Category 4 - This comment relates to the proposed sediment stability study and to evaluation of reliability and effectiveness of dredging, both are which are important but beyond our current scope.	It is recommended that the HC-2014-044 comment be taken into account in further studies/reports.

	would gradually increase above the proposed SeQOs through sediment movement due to waves, wind, propeller wash, etc. Furthermore, the sediment movement patterns appear to be poorly understood and study of sediment movement can be considered a prerequisite to finalization and implementation of the ultimate management strategies. It is not understood how long the contaminant levels in the proposed management zone (Map V-8) will remain within the SeQOs and also how the risk would change as contaminant levels gradually rise above those SeQOs. Also, there is little or no sediment data available for the sediments in the marina area and the data along the shoreline north of the marina is very sparse. If TC was to consider doing any additional sediment sampling, these areas would warrant further investigation. The lack of data in that area is also of concern as this elevated contamination is outside the proposed management area and potential human health risks may not be properly and completely assessed or mitigated. It would seem appropriate that one of the goals in any remedial strategy would be that a managed or dredged area does not become recontaminated, such that future		

	site use does not result in new risks to human health.		
HC-2014-045	[Chapter V - Sediment Management Goals for the KIH] • It is not clear whether the exposure point concentrations (EPCs) were derived from sediment data for all depths or whether only certain depths were considered. ESG notes that two samples at depth with exceptionally high PAH concentrations in one area and two samples at depth with exceptionally high antimony concentrations in another area were not included when the EPCs were developed. It would thus appear that all data were included regardless of depth (except the aforementioned four samples). If TC were to develop a revised HHRA, they could consider whether they can define a depth at which exposure would no longer be expected (i.e., people and aquatic organisms would not come into contact with these sediments as they are buried and are at a depth where they are not expected to be exposed as a result of regular activities and conditions in the harbour). They could consider excluding the data from below this depth from the statistics used to define EPCs. Any contamination at depth that is excluded from the risk assessment would need to be risk managed and it would need to be ensured to the extent practicable that the sediments	Category 1b - Agree with comment. Per the advice, for risk assessment, we will define a depth at which exposure would not be expected, but will retain understanding of contamination at depth as part of remedial options evaluation.	Satisfactory response. No further comment.

	remain buried. If it is later proposed that they be exposed (e.g., due to dredging), they would need to be incorporated into the risk assessment and/or managed appropriately.		
HC-2014-046	[Chapter V - Sediment Management Goals for the KIH] • Although responses to reviewer comments (Appendix M) allude to some of the changes made in the revised report, it would be helpful if the report author could provide additional supporting documentation for those changes and point out/justify any changes made that weren't addressed in the documented responses to reviewer comments.	Category 4 - Comment relates to RMC-ESG deliverable only.	No further comment.
HC-2014-047	[Chapter V - Residual Risk and Uncertainty Analyses] • As noted in this review, there are additional uncertainties that need to be considered that are not considered here (discussed elsewhere in this review).	Category 1b - To be addressed in uncertainty analysis.	Satisfactory response. No further comment.
HC-2014-048	[Chapter V - Considerations for RAP Design] • Ongoing site and risk assessment studies will be required prior to development and implementation of a remedial action plan (RAP). The text is correct to note that uncertainties are present and need to be addressed.	Category 4 - We agree.	No further comment.

HC-2014-049	[Chapter V - Conclusions and Recommendations] • As noted earlier, contrary to the assertions in the ESG report (reiterated in the Conclusions and Recommendations), based on this review and the review completed by Golder, there appears to be considerable work remaining before developing and implementing a remedial action plan for KIH.	Category 4 - We agree.	No further comment.
HC-2014-050	[Chapter V - References] • The reference section does not include the required reference to the Treasury Board Policy on Management of Real Property	Category 4 - Comment relates to RMC-ESG deliverable only.	No further comment.
HC-2014-051	[Chapter V – Minor Comments] • The text on page 11-19 notes that among the 4 SARA species of turtles, some have "endangered" status; however, none of the 4 turtles listed in Table V-3 on page 11-20 are noted to be endangered.	Category 1b - Will be clarified as part of the assessment of listed and endangered species.	Satisfactory comment. No further comment.
HC-2014-052	[Chapter V – Minor Comments] • The sediment stratigraphy of selected cores collected in the KIH is shown in figure V-l (not Figure V2 as noted in the text on page III-8).	Category 4 - Comment relates to RMC-ESG deliverable only.	No further comment.
HC-2014-053	[Chapter V – Minor Comments] • It appears that, for clarity, the title of map V2 should be "Arsenic Map of 6 ppm of surface sediments in KIH": the current title	Category 4 - Comment relates to RMC-ESG deliverable only.	No further comment.

	excludes "ppm".		
HC-2014-054	[ESG Report Format and Geographical References] • The report is lengthy (1027 PDF pages) but does not provide PDF bookmarked sections or an overall table of contents. This makes the report extremely difficult to navigate and to find supporting tables, calculations and figures. Thus, it is suggested that these and other changes noted herein would improve the overall readability and accessibility of the report.	Category 4 - Comment relates to RMC-ESG deliverable only.	No further comment.
HC-2014-055	[ESG Report Format and Geographical References] • Another notable challenge with navigating the report stems from the fact that KIH is defined in the report Executive Summary as the stretch of the Cataraqui River between the 401 and the Lasalle Causeway. It would perhaps be more practical to define the KIH as the stretch of the Cataraqui River between Belle Island and the Lasalle Causeway since this appears to be a conventional reference and the bulk of the study area figures are labelled that way and only show that stretch. Furthermore, the area contains the federal water lots in question and the numerous unique and geographically separate zones of contamination. The lengthy stretch north of Belle Island to the 401 is spatially	Category 2 - Completely agree that we must be clear in defining the studied area, or sub-areas within. Would like to discuss with FCSAP to make sure that terminology is clear and broadly supported.	Satisfactory comment. No further comment. HC is available to discuss/review the proposed approach at custodians' request.

	extensive, is labelled in part as the Rideau Canal (Figures 1-1 and I-2 in Chapter 1), and is considered to be uncontaminated and is not characterized in the report to the same extent (serves as background data for comparison with contaminated areas south of Belle Island).		
HC-2014-056	[ESG Report Format and Geographical References] • As noted in Golder's review, the southern area (between Belle Island and the Lasalle Causeway) is treated in the ESG report as a single exposure area or APEC, and the numerous contaminated zones that are spatially-separated and unique in their contamination issues are grouped together as the "southwestern KIH". It would be easier to locate/visualize specific issues/areas if the numerous unique contaminated zones were identified more frequently in the text in terms of their geographical (northwest, southwest, etc.) localization within this exposure area/APEC. Instead, the current text refers regularly to contamination by families of contaminants (i.e. metals, PAHs, etc.) and specific contaminants (chromium, mercury, etc.), in the "southwestern" KIH (i.e. southwest of Belle Island). This is very imprecise/ambiguous in geographical terms, given the numerous unique contaminated zones in the exposure	Category 1b - Our specification of new management areas, along with resolution of issue HC-2014-055 should take care of this.	Satisfactory comment. No further comment.

	area/APEC, including in its southwest portion.		
HC-2014-057	The Golder memorandum is well written and is a good high level synopsis/analysis of the final ESG report and HC ES provides the following general comments.	Category 1a - Thank you; no response required.	No further comment.
HC-2014-058	With reference to the Golder (2013) source investigation for the southwest TC water lot, Golder notes that recent findings have shown that in many areas, offshore PAH concentrations exceed those along the shoreline. Furthermore, it is noted that coal tar has historically been observed in core samples in the vicinity of Anglin Bay and that historical deposition of coal tar may be a significant source of PAH contamination within Anglin Bay sediments. This is important when considering management options related to PAHs and their impact on human health.	Category 1b - Agree with comment. Concentrations of PAHs in near-surface sediments will be addressed in upcoming risk refinement, both in terms of spatial distribution and associated risks to all receptor groups. Additionally, contamination at depth should be considered in future remedial options evaluation.	Satisfactory response. No further comment.
HC-2014-059	As noted by Golder, background exposure to PCBs does not appear to have been considered in the human health risk assessment, in identifying special management areas or in the development of sediment quality objectives. However, a hazard quotient of 1 was applied rather than the Health Canada default of 0.2 for risk estimates developed without consideration of background. The Health	Category 2 - Rather than apply the Health Canada default of 0.2 for risk estimates developed without consideration of background, it may be feasible to adjust exposure to include background sources. Because much of PCB exposure to urban residents in the Great Lakes comes through dietary consumption, use of a baseline ingestion for a typical resident could be added to the site-specific exposure from	Satisfactory response. Please ensure to provide adequate, scientifically-based rationale and referenced data for any assumptions made, should a threshold hazard quotient different than 0.2 be used for PCBs.

	Canada default HQ of 0.2 is typically applied where background (off-site) exposures (e.g., from food, consumer products, water and air) have not been considered in order to minimize the chance that total exposure (site + background) does not exceed the tolerable daily intake. HC concurs that further justification should be provided for the use of a threshold hazard quotient other than 0.2 where background exposure is not considered.	recreational exposure to KIH. This approach may yield a less conservative but more relevant estimate to use of default of 0.2.	
HC-2014-060	Golder points out a number of areas where they concur with ESG, as well as several areas that they do not. Golder's review brings into question some of the methodologies employed by ESG in assessing health risks, and the conclusions and proposed management decisions drawn from obtained results. In this regard, our HC ES review of the ESG report is in line with the Golder review in that there still appears to be a lot of uncertainty with regards to the estimated level of risk to human receptors and what possible mitigations could be implemented to manage those risks to human health. HC ES concurs with Golder that additional work is needed with regards to assessing and managing contamination within the KIH in order to address those uncertainties	Category 1b - Thank you; no response required.	No further comment.

	and thereby more accurately characterize the risks to human health associated with KIH. To this end the ESG report is a valuable body of data that can potentially support additional assessment and management work on-site.		

Health Canada Santé Canada

Environmental Health Programme, RAPB
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February 6, 2015

Brent O'Rae
Contaminated Sites Ecologist
Parks Canada
635-8th Avenue South West, Suite 1550
Calgary, Alberta T2P 3M3

Dear Brent,

Subject: Review of Golder's responses on June 2014 Health Canada Comments on Kingston Inner Harbour Sediment Assessment

Health Canada reviewed responses to Health Canada comments (dated June 27, 2014) contained in the January 12, 2015 Technical Memorandum entitled *"Draft Responses to the FCSAP Expert Support Comments on Kingston Inner Harbour 2014 Reporting Package"* authored by Golder Associates, which is in response to FCSAP Expert Support comments on the RMC-ESG report entitled "*Application of the Canada-Ontario Decision-Making Framework for Contaminated Sediments in the Kingston Inner Harbour*" (dated February 2014) and on Golder's memorandum entitled "*Review of Revised RMC Reporting on Kingston Inner Harbour Sediments*" (dated March 31, 2014) and provides additional follow-up comments where warranted. The review was completed as per our role as an Expert Support Department under the Federal Contaminated Site Program (FCSAP). Our comments are attached.

From Golder's responses, we understand that the RMC-ESG document will not be revised (or that this is beyond Golder' scope or control) and that Golder will only work on a risk refinement deliverable. Regardless, several Health Canada comments related to the RMC-ESG document still stand and could be considered in the event of any future revision of this document, or could be included as part of an addendum to the current document (so that it is transparent which comments were and were not addressed). In addition, more specifics on what will be included or not in the upcoming risk refinement deliverable would be appreciated. It is recommended that all relevant information, calculations, assumptions, etc. regarding the human health risk assessment be provided in the risk refinement deliverable, to facilitate peer review and verification of assumptions. It could also be important for Transport Canada's and Parks Canada's health risk communication purposes to have a "stand alone" document that includes all pertinent data, assumptions, etc. As Golder Associates undertakes additional "risk refinement" work on behalf of Transport Canada and Parks Canada, Health Canada is able to provide advice and guidance on this site, where desired.

Health Canada Santé Canada

Please contact the undersigned if you have any questions with respect to these comments or human health risks and risk management for this site or any other sites.

Sincerely,

Adam Griffiths

Adam Griffiths, M.Sc.
Health Risk Assessment & Toxicology Specialist

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MEMO: Health Canada Review of Golder's responses on June 2014 Health Canada Comments on Kingston Inner Harbour Sediment Assessment

Document title: Draft Responses to the FCSAP Expert Support Comments on Kingston Inner Harbour 2014 Reporting Package
Document author: Golder Associates Ltd.
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Thank you for the opportunity to review and provide comments on the draft consultant responses to Health Canada comments contained in previous FCSAP Expert Support comments on two 2014 reports related to Kingston Inner Harbour (report on the application of a decision-making framework to contaminated sediments and a report on Kingston Inner Harbour sediments); responses were contained in the above mentioned document.

Health Canada provides these comments as per our role as an Expert Support department for the Federal Contaminated Sites Action Plan. These comments are in no way to be interpreted as any type of approval, authorization, or release from requirements to comply with federal statutes and regulations.

HC Follow-Up Comments on Golder's Responses dated January 12, 2015

Reference Number	Original HC Comment (June 27, 2014)	Golder Response (January 12, 2015)	HC Follow-up Comment (February 6, 2015)
HC-2014-001	Our understanding is that, with the exception of perhaps some early studies, this report has generally not been prepared on behalf of, or funded by, either of the Custodial departments (Parks Canada (PC) and Transport Canada (TC)) that own the Kingston Inner Harbour (KIH) water lots that comprise the main study area. Health	Category 1b - Agree with comments; such concerns have resulted in the risk refinement report being conducted.	Satisfactory response. No further comment.

	Canada (HC) in its FCSAP Expert Support (ES) role continues to support these custodial departments by providing human health related comments on ongoing KIH reporting, at their request. It is noted that, although ESG has to a limited degree made an effort to incorporate a selection of the more recent work completed by others on behalf of the custodial departments, the ESG report uses wording that implies that there is a general consensus that the ESG report is the definitive study regarding the KIH, that its methodology and conclusions have been adopted and that the next steps in KIH sediment management are evident as a result. Concurrent KIH studies completed on behalf of TC (Golder, 2011, 2013, 2104, etc.) indicate that this is not accurate. Furthermore, PC and TC have indicated that human health and environmental site and risk assessment is ongoing and that support from ES Departments (ESDs, i.e. EC, HC and DFO) will continue to be sought as the Custodians manage their respective water lots.		
HC-2014-002	We have focused our review of the ESG report on the parts of the report relating to our mandated areas (i.e. potential risk to human health) and other ESDs have done	Category 1b - Following review of the full FCSAP Expert Support comment package, we agree that decisions may be significantly affected. At the same time,	Satisfactory response. It is suggested to consider issues that may significantly impact the human health risk assessment outcomes

	the same with regards to their mandates. Based on a review of the human health related sections of the above noted documents, HC recommends that the results of the human health risk assessment (HHRA - Chapter IV of the ESG Report) and the management options analysis (Chapter V of the ESG report) be considered within the context of the comments provided herein, as some comments are significant in nature and thus may impact the interpretation of the HHRA and any decisions stemming from it.	we do not have the scope to repeat or revise all aspects of the RMC-ESG risk assessment, nor do we believe that such is warranted. Instead, we recommend that select key assumptions/parameters be revaluated quantitatively, focussing on those decisions that most significantly influence risk outcomes, and we are soliciting additional Expert Support input on some of these topics. The overall objective is to evaluate the consequences for overall risk characterization; in some cases this will entail revision of HQ estimates whereas in other cases a narrative discussion in the uncertainty assessment will suffice.	and resulting decisions on next steps in KIH sediment management.
HC-2014-003	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • With the exception of antimony, the suite of metals included in the list of COPCs for the lower Kingston Inner Harbour (KIH) appears to be limited to those with Canadian Council of the Ministers of the Environment (CCME) sediment quality guidelines. The report includes raw data and a summary of sediment data only for the COPCs (i.e., maximum, minimum, mean and 95% upper confidence limit of the mean {UCLM}) and it is not clear whether other metals were analyzed or considered in the	Category 1b - Additional screening information will be provided in the risk refinement deliverable. Where CCME guidelines are not available, we will consider comparisons to sediment guidelines from other jurisdictions, soil guidelines if necessary, and will consider whether substances associated with relevant industrial activities have been captured in the screening (e.g., Health Canada Part I *Table A2 Contaminants Commonly Associated with Various Governmental and Industrial Activities*).	More details are needed on selection of COPCs before agreeing with Golder's response. Please note that, to ensure an approach that is fully coherent, rigorous and defensible regarding the objectives of an HHRA, Health Canada's Contaminated Sites Division recommends, for the identification of chemicals of potential concern (COPCs) on a particular site, a comparison of concentrations of chemicals against criteria that are protective of human health.

	COPC screening process. It appears, based on the summary of previous investigations in the KIH provided in Chapter II, that a full suite of metals has been analyzed for at least a subset of samples from the lower KIH. We also note that data for VOCs in sediment are reported for one sample from the KIH in a previous version of Chapter II, including relatively low but measureable concentrations of BTEX, isopropylbenzene and trimethylbenzene. Summary data for all substances measured in sediments in KIH should have been included in the report along with the screening values used and the corresponding data from the reference site, where applicable. Substances with no CCME screening value should be screened against appropriate screening values from other jurisdictions and/or data from reference sites, where available. In cases where no screening values are available, the substances should be carried forward as a COPC unless it can be clearly shown that concentrations in sediments in the lower KIH are not significantly different than those in the reference area and that there are no hot spots or areas with locally elevated sediment concentrations. Transport Canada and Parks Canada may wish to evaluate the raw sediment data from their respective properties to		Currently, there are no human health-based sediment criteria published from a Canadian jurisdiction. The few human health-based sediment criteria currently available from other jurisdictions would not be directly applicable to most Canadian federal contaminated sites as they generally do not consider all potentially relevant pathways. In some cases, in the absence of applicable human health-based sediment guidelines, sediment concentrations may be screened against available human health-based soil criteria for residential/parkland use for a direct contact scenario. These criteria were developed based on exposure factors specific to human interactions with soil. Given that human exposure to sediments is typically different from human exposure to soil (e.g., potentially greater dermal adherence and ingestion rates), the soil quality guidelines may not be sufficiently protective of human health for some sediment exposure scenarios. In particular, for a site where people are expected to visit the site

	determine whether any other substances should have been retained in the risk assessment.		regularly to participate in high contact-type activities (e.g., playing on the shoreline and in shallow water, picnicking, etc.) the soil quality guidelines may not be a sufficiently conservative screening tool. In this case, site-specific screening values could be derived. Alternatively COPCs may be identified by comparing site data with regional background data. In situations where soil quality guidelines are considered relevant and appropriate for screening, only the human health based guidelines for the relevant corresponding sediment exposure pathways should be considered. In particular, at many sites, incidental ingestion of and dermal contact with sediments may be the only operable pathways. In this case, only the human health-based soil quality guidelines for dermal contact and incidental ingestion would be considered relevant sediment screening values. In some cases, guideline values for inhalation of particulates may be relevant if sediments dry out periodically. For the purposes of screening federal sites, the relevant CCME

			Canadian Soil Quality Guidelines (SQG) for human health would generally be considered the most appropriate screening values. Where human health-based CCME SQGs are unavailable, human health-based soil quality guidelines from another jurisdiction may be selected provided they offer the same level of protection inherent in the CCME SQGs. In some cases, a guideline from another jurisdiction may need to be adjusted to account for differences in how the guidelines were developed, including health protection endpoints and the apportionment of the tolerable daily intake. In situations where the soil quality guidelines are used for screening, sufficient rationale must be provided for why the soil-based screening values are considered sufficiently conservative for screening sediments and the uncertainties associated with the selected criteria should be noted. Soil criteria do not account for the potential for chemicals to bioaccumulate or biomagnify in the aquatic food web. Therefore, they

			are not suitable for identifying bioaccumulative or biomagnifying substances that should be considered in evaluating risks associated with the consumption of seafood (i.e., fish, shellfish, aquatic vegetation or aquatic birds) from the site. COPCs for the seafood consumption pathway may be screened using the following approach: (1) Identify biomagnifying and potentially bioaccumulative chemicals that are site-related and present in sediments at the site above industry standard detection limits and above local background levels; (2) In some circumstances, screening based on sediment data may be supported by screening based on seafood tissue data. In particular, seafood tissue chemistry from the site may be compared to seafood tissue chemistry from a reference site, and/or applicable seafood

			screening criteria for the seafood consumption pathway, if available. To ensure that no additional COPCs should have been considered in the HHRA, it is suggested to review the selection of COPCs (by using human health-based environmental quality guidelines) or to justify the approach retained in this study and to identify its possible effects on the results.
HC-2014-004	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • The portion of the KIH north of Belle Island (i.e., the upper KIH) has been selected as the reference area. The report notes that this portion of the KIH has been minimally impacted by past industrial activities. The former Belle Park landfill forms part of the southern border of the upper KIH and it is not clear whether the former landfill has impacted sediments in this area as the former landfill is listed as a source of COPCs to the lower KIH. Also, it is not clear whether there were any other potential historical sources of contamination to the upper KIH. We note that the 95% UCLM for reference data appears to be higher than the Ontario sediment screening values and Ontario	Category 1b - Although there are a few areas north of Belle Island that exhibit sediment concentrations higher than in other reference areas, the vast majority of stations have exhibited concentrations of COPCs that are much lower than along the western half of the southern KIH. Furthermore, sampling of reference stations for effects data (e.g., benthic community assessment, toxicity testing) and for bioaccumulation assessment has emphasized the areas of the upper KIH that have been least influenced by urban contamination. As noted above, the retention of most substances (irrespective of the statistical comparisons to reference) means that risk characterization outcomes are not sensitive to the details of this screening. To address this concern,	Satisfactory response. No further comment.

	background concentrations for most metals and for PCBs. It appears that all sediment COPCs listed in Table II-2 and Tables IV-3JV-5, IV-7 were retained even if the data from the KIH was not considered significantly greater than the data from the reference area. Therefore, any issues related to the selection of sediment reference sites would not be expected to have any implications for overall findings of the human health risk assessment (HHRA) as they pertain to the COPCs that were presented in Chapter IV. If substances with no sediment screening values were compared with data from the reference area, the data from the reference area may need to be re-evaluated to confirm that there are no areas of localized contamination (e.g., adjacent to the former Belle Park landfill) that would bias the reference data high.	calculations of averages in the risk refinement will exclude data points that may reflect areas of localized contamination that would bias the reference data high.	
HC-2014-005	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • It appears that COPC concentrations in sediments for the entire lower KIH (below Belle Island) were used to compare the impacted areas to the reference area. We do not agree with this approach. For most COPCs, the impacted area in the lower KIH is localized primarily to the western portion of the	Category 2 - We agree with the comment, and have proposed to develop management areas that integrate sediment bed zones with similar contamination profiles. We would like to discuss our approach with Expert Support to confirm that the divisions of the impacted area are of an appropriate scale.	Satisfactory response. HC is available to discuss/review the approach at custodians' request.

	lower harbour, while the eastern portion of the lower harbour appears to be relatively unaffected by the sources along the western shore. For each COPC, only data from the impacted sediments should be used to compare impacted areas with the reference area. For example, based on information provided on Map 11-10, arsenic concentrations in sediments exceeding the ISQG appear to be limited to the western portion of the shoreline, extending between 200 m and 400 m offshore (an area that may occupy only approximately one third of the lower KIH). Arsenic concentrations in sediments exceeding the PEL are limited to a much smaller area along the central portion of the shoreline of the lower KIH. Map 11-10 clearly shows a distinct area of sediments impacted by arsenic and data from areas that are not impacted should not be included in the comparison between the impacted portion of the lower KIH with data from the reference area.		
HC-2014-006	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • It is not clear where fish tissue reference data were collected and sufficient rationale was not provided to support the selection of the reference location. In particular, it was not clear whether the home range of fish from the reference area	Category 1b - The location of both exposed and reference tissue collections have relevance to the risk refinement, as we will be linking tissue collections to areas of KIH. RMC-ESG has provided sufficient information of the location of fish samples to make these assignments. Additional details will be provided in the	Satisfactory response. No further comment.

	could include the KIH or whether there are potential sources of COPCs in the reference area. The Ontario Ministry of Environment (OMOE) Sport Fish Contaminant Monitoring Program could be contacted for further guidance. It may also be useful to determine whether OMOE considered metals other than mercury and chromium when they established the fish consumption advisories for the KIH.	risk refinement deliverable.	
HC-2014-007	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • We could not find details regarding the statistical analyses used to compare data from KIH to the reference area. Therefore, we could not check the approach and interpretation.	Category 1a - The statistical comparisons will be revised based on the division of water lots into management zones, and through exclusion of anomalous reference concentrations, both per previosu comments for Expert Support. Therefore, the details of what was done in the RMC-ESG deliverables will no longer be applicable.	Satisfactory response. No further comment.
HC-2014-008	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • Tables in Section B.I of the HHRA include Ontario Ministry of Environment (OMOE) sediment quality standards but not CCME sediment quality guidelines. Given that the KIH is under federal jurisdiction, the CCME sediment quality guidelines should also be considered for screening sediments, unless agreements between Federal and	Category 1b - The work conducted by Golder for Parks Canada and Transport Canada has already considered CCME sediment quality guidelines (where applicable) and has also considered guidelines from other jurisdictions. The risk refinement report will continue with this approach.	Please ensure this clarification is included in the report. Also please see response HC-2014-003.

	Provincial governments are in place that would warrant the use of OMOE sediment quality standards.		
HC-2014-009	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • The tissue screening value of 0.5 mg/kg for mercury cited in Table IV-9 was developed by Health Canada for retail fish and, in some cases, may not be an appropriate value for screening sport fish tissue as consumption patterns for sport fish may differ than those that were assumed for retail fish for the purposes of developing the retail fish screening value. The OMOE consumption guidelines listed in Table IV-9 appear to be from the 2009-2010 Guide to Eating Sport Fish and would likely represent a more appropriate screening value for tissue concentrations in sport fish, provided the assumptions regarding sport fish consumption used to derive the values are reasonably representative of consumption patterns expected at the KIH.	Category 1b - This information will be considered in the risk refinement.	Satisfactory response. No further comment.
HC-2014-010	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • Please note that the FDR/HC guidelines for arsenic and lead in fish protein cited in Table IV-9 apply to powdered fish protein and do not apply	Category 2 - We agree with the comment and propose to reassess the technical basis for screening of arsenic and lead through dietary consumption.	Satisfactory response. No further comment.

	point sources). It appears that the FDR/HC guidelines were used to screen out arsenic in fish tissue as the reference data could not be used for screening, although this was not explicitly stated. Arsenic concentrations in all of the reference samples were below the detection limit but the detection limit for the reference samples exceeded the maximum concentration measured in fish tissue from the study area. Further rationale should be provided for screening out arsenic in fish tissue, including justification for the use of the FDR/HC guidelines.		
HC-2014-011	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • Based on correspondence between HC and OMOE between June 24 and 26, 2014 the fish consumption advisories for the KIH are based on PCBs, mercury and chromium. It appears that mercury and chromium have been excluded as a COPC in fish tissue based on a comparison of site data with reference data. At a minimum, it should be acknowledged that OMOE has established fish consumption advisories in the KIH based in part on mercury and chromium in fish tissue.	Category 2 - Agree with comment; the basis for consumption advisories will be discussed in the risk refinement report, and implications for screening of pathways and substances considered.	Satisfactory response. No further comment.
HC-2014-012	[Chapter IV - Selecting and Screening	Category 2 - Agree with comment; the	Satisfactory response. No further

	directly to fish tissue. According to the Food and Drug Regulation, fish protein "(a) shall be the food prepared by (i) extracting water, fat and other soluble components through the use of isopropyl alcohol from fresh whole edible fish of the order Clupeiformes, families Clupeidae and Osmeridae and the order Gadiformes, family Gadidae, or from trimmings resulting from the filleting of such fish when eviscerated, and (ii) drying and grinding the protein concentrate resulting from the operation described in subparagraph (i); (b) may contain a pH adjusting agent; and (c) shall not contain (i) less than 75 per cent protein, which protein shall be at least equivalent to casein in protein quality, as determined by official method FO-1, Determination of Protein Rating, October 15, 1981." Sufficient rationale is not provided to justify application of these guidelines for screening fish tissue concentrations. We note that lead in fish tissue was not retained for further evaluation as the concentrations in the KIH were not significantly different from those in the reference area. Therefore, use of these screening values would not impact the overall finding for lead (provided that reference samples have not been impacted by the sources in the lower KIH or other		

	Contaminants of Potential Concern (COPCs)] • The text states in several locations that there is strong evidence that chromium from sediment is bioaccumulating into aquatic organisms. Also, as noted above, the fish consumption advisory for the KIH is based in part on chromium levels in fish tissue. The maximum and 95% UCLM for chromium in tissue from the study area are more than double those in the reference area. However, chromium in fish tissue from the reference area was found to be not statistically different from that in the study area. Therefore, chromium was not retained as a COPC in fish tissue. Parks Canada and Transport Canada may wish to confirm the validity of the reference samples and the statistical analyses given that Cr is shown to be bioaccumulating. Also, in any future evaluations of health risk associated with consumption of impacted fish in the lower KIH, it should be acknowledged that OMOE has established fish consumption advisories in the KIH based in part on chromium in fish tissue.	basis for consumption advisories will be discussed in the risk refinement report, and implications for screening of pathways and substances considered.	comment.
HC-2014-013	[Chapter IV - Selecting and Screening Contaminants of Potential Concern (COPCs)] • Based on information in the OMOE (2010) report Cataraqui River	Category 1b - See response DFO-2014-005; the risk refinement will exclude data for locations within the dredge footprint that were collected prior to dredging	Satisfactory response to HC June 27, 2014 comment. Older data may also not reflect

	Project Track-Down: Follow-up Study on Success of Remediation Efforts in the Cataraqui River 2006, it appears that sediments adjacent to Emma Martin Park were dredged in late-2004. However, based on information in Table II-1, it appears that eight of the twelve sediment sampling programs used to map the spatial extent of COPCs were completed prior to 2004. The report does not mention the dredging program off Emma Martin Park and it is not clear whether data that were collected from the dredged area prior to dredging were included in the risk assessment. It is recommended that the database be re-evaluated to confirm that data included in the risk assessment represent post-dredging conditions and that data from sediments that were removed from the KIH were not included.	program off Emma Martin Park.	current conditions, given that sediment are subject to disturbance, movement and resuspension and that chemicals are subject to environmental degradation, and may prevent the site assessor from drawing appropriate conclusions. HC recommends to assess the reliability of site data used. A rationale should be provided to explain which data is considered relevant or why older data is still relevant.
HC-2014-014	[Chapter IV - Defining Exposure Point Concentrations] • Given the substantial amount of sediment data available for the KIH, we agree with using a statistic other than the maximum measured concentration to represent the exposure point concentration. However, we do not agree with the use of 95% UCLM for the entire inner harbour to represent the exposure point concentrations for human receptors or to screen out COPCs. Based on the	Category 2 - Golder agrees with the general point being made, and proposes to address the issue through use of management zones rather than through calculation of the 95% UCLM for the entire contaminated zone. The objective will not be to identify small scale "hotspots" but rather to identify areas that may be expected to integrate exposures differently from other zones. We would like to liaise with Expert Support to	Satisfactory response. No further comment. HC is available to discuss/review the approach at custodians' request.

	information provided in Maps II-6 through 11-16, it appears that there are hot spots or localized areas of higher concentrations for each of the COPCs (typically along the western shored) and for most COPCs it appears that at least half of the KIH (typically the east half) has relatively low concentrations (i.e., below the PEL and in some cases below the ISQG). Given the large area represented by the KIH, individuals would not be expected to be exposed to all sediments in the entire harbour equally. Instead, it would be expected that an individual would spend time within a smaller area within the harbour. Different individuals may spend time in different areas of the harbour and, with the exception of boaters, activities would be expected to be , focused at or near the shoreline. Given that the hot spots for most COPCs appear to be localized at and/or near the shoreline on the western side of the KIH, some people may be expected to be exposed to average COPC concentrations that are substantially higher than the" 95% UCLM for the entire harbour. For example, based on the contaminant concentration profiles in Maps II-6 and 11-12, the highest concentrations of antimony and chromium appear to be found primarily in the area south of Cataraqui Park, east of Orchard	confirm that the number of zones identified is appropriate for the assessment of human and wildlife health risks; these pathways will combine exposure over multiple areas, through their own foraging behaviour and through the movements of prey.	

	Street Marsh. This area also has lead concentrations in sediment that are substantially higher than most of the rest of the harbour (see Map II-7). If a receptor were to visit this area, the average sediment concentrations of antimony, chromium and lead to which they would be exposed would be substantially higher than the 95% UCLM for the entire harbour. The human health risk estimates based on the 95% UCLM for the entire harbour should not be considered reliable estimates of potential risks for individual receptors accessing the shoreline at various locations along the western shore of KIH. Health risks associated with exposure to chromium, copper, zinc, DDT, chlordane, naphthalene and pyrene were considered acceptable based on exposure to the 95% UCLM for the entire harbour. However, for receptors who visit areas with localized higher concentrations of COPCs in sediments (e.g., the area adjacent to orchard street marsh and Belle Park and the area between the marinas and Emma Martin Park) potential health risks may be substantially higher than predicted as these receptors would be exposed to an average sediment concentration that is substantially higher than the 95% ULCM for the entire harbour.		

HC-2014-015	[Chapter IV - Defining Exposure Point Concentrations] • Special management areas: Section F of the HHRA introduces the concept of special management areas (SMAs), which appear to be areas with localized higher concentrations of a particular COPC. Special management areas appear to be defined only for arsenic, mercury, PCBs and PAHs based on considerations related to human health and for chromium and PCBs based on considerations related to ecological health. The human health risk assessment presents risk estimates for arsenic and mercury within the SMA and for arsenic and mercury outside the SMA. The exposure point concentrations defined for the SMAs may provide a more realistic estimate of the concentrations that people who visit this area may be exposed to (depending on how they were defined relative to the contaminant distribution and relative to the areas that people may frequent) resulting in more realistic risk estimates for these receptors. There appears to be an area of localized elevated mercury concentrations in sediments outside of the SMA in the vicinity of the marinas. The use of the 95% ULCM mercury concentrations in sediments for the remainder of the KIH outside of the SMA to estimate risk for human receptors would not account for this	Category 2 - See response HC-2014-014 above. We were also confused by the concept of special management areas (SMAs) because there was not a clear articulation of why SMAs were developed for some pathways and substances but not for others. As before, we would like to confirm the scale of management areas that best strikes a compromise between the need to average exposures over areas (for realism and relevance to plausible exposure scenarios) and the need to acknowlege larger contiguous areas of sediment that have a different contamination profile than other parts of the harbour.	Satisfactory response. No further comment.

	hot spot where people may be exposed to substantially higher concentrations throughout the area. If people are expected to be exposed to COPCs in sediments in areas with locally elevated concentrations, health risks should be evaluated for these areas using an exposure point concentration that is representative of the area where an individual may be exposed.		
HC-2014-016	[Chapter IV - Defining Exposure Point Concentrations] • Table IV-22 provides HQ values for arsenic, inorganic mercury and lead that have been adjusted for background exposure, such that a threshold of 1 would be more appropriate than a threshold of 0.2 for defining potentially unacceptable risk. The HQ values reported for the area outside the SMA would only be an appropriate representation of human exposure outside the SMA if the sediment concentrations outside the SMA are relatively uniform throughout the entire KIH and there are no significant hot spots or areas where COPCs are locally elevated. As noted above, there appears to be at least one significant hot spot of mercury in sediments outside of the SMA in the vicinity of the marinas. Therefore, the HQ values reported for mercury in sediments outside the SMA (which are based on a 95% UCLM for the entire harbour outside	Category 1b - This concern should be addressed through the specification of new management areas, and/or through adjustment of the screening HQ to 0.2 for As, Hg and Pb.	Satisfactory comment. No further comment.

	the SMA) may not accurately reflect potential risks for people who would be exposed to mercury in sediments in the vicinity of the marinas. Likewise, the lead HQ for the entire KIH would not be representative of human exposure in areas with locally elevated concentrations along the shoreline.		
HC-2014-017	[Chapter IV - Defining Exposure Point Concentrations] • Two samples from the outlet of the Orchard Marsh at depths of 17.5 cm and 52.5 cm with antimony concentrations substantially higher than most of the rest of the KIH were removed from the data set and human health risks were re-calculated based on the 95% UCLM of the remainder of the data set for the KIH. No rationale was provided for removing these two samples. If it is presumed that people would not be exposed to sediment at these depths and if surficial sediments in these areas have been characterized, it may be reasonable to remove these samples from the data set. However, as noted previously, the 95% UCLM for the entire KIH may underestimate risks to people who would access the shoreline in the vicinity of Orchard Street Marsh, Cataraqui Park and the former lead smelter as there appears to still be sediments with elevated antimony	Category 1b - Samples collected at depth will be removed from the database used to assess present-day risks. However, contamination at depth will be considered in the future pending the outcome of the risk refinement. The risk refinement will include rationale for screening on sediment chemistry data in the vertical dimension.	Satisfactory response. No further comment.

	concentrations well above the CCME soil standard in this area even when the two samples at depth are excluded.		
HC-2014-018	[Chapter IV - Defining Exposure Point Concentrations] • Pg II-6 (Chapter IV): Samples with elevated PAH concentrations at depths ranging from 31 to 123 cm collected from the Anglin Bay area with "extremely high concentrations of PAHs" (total PAHs 18-20,600 mg/kg) were excluded from the risk assessment. The rationale provided was as follows: "Anglin Bay is an area not expected to encounter much use in terms of wading or even swimming and thus these depth samples are unlikely to be available to pose risk to humans." However, text on page II-2 (Chapter IV) states that the docks located near the LaSalle Causeway and Anglin Bay are often used for swimming and other water-related recreational activities. We agree that exposure to the deeper sediments with elevated PAH concentrations is unlikely provided they are not exposed due to disturbance of surficial sediments (e.g., due to prop wash). Further rationale for excluding these samples is recommended, including confirmation that the area of contamination has been delineated (including data for the surficial sediments in the area), the	Category 3 - See response HC-2014-017 above. The clear distinction between present-day risks based on near-surface chemistry, versus potential risk scenarios through sediment disturbance, needs to be made. In the case of sediment PAHs, the very high concentrations of PAHs in some samples (i.e., hazardous waste) also warrant consideration in the remedial options analysis.	Satisfactory response. No further comment.

	location of the sediments relative to areas where people are expected to swim or wade and confirmation that the surficial sediments overlying the sediments with "extremely high PAHs" are not expected to be disturbed. If these sediments are excluded from the risk assessment, they may still need to be risk managed to ensure that they do not become exposed/uncovered (e.g., if overlying sediment were to be dredged, these deeper sediments with substantially higher PAH concentrations could become exposed).		
HC-2014-019	[Chapter IV - Defining Exposure Point Concentrations] • As noted previously by Health Canada in comments provided in a letter dated June 18, 2010 and by Golder Associates in their technical memorandum dated March 31, 2014, dioxin-like PCBs are not explicitly addressed in the risk assessment. The report does not note whether dioxin-like PCB congeners have been analyzed in sediments in the lower KIH. OMOE (2010) report congener specific PCB concentrations in their report Cataraqui River Project Track-Down: Follow-up Study on Success of Remediation Efforts in the Cataraqui River 2006. If sufficient data are available, they should be considered in the risk assessment. If the data are not available,	Category 2 - We would like to discuss this issue with Expert Support, given that previous feedback has been that Health Canada does not evaluation dioxin-like PCBs as carcinogens, but rather as non-carcinogens using the hazard quotient method. However, methods for assessing dioxin-like PCBs quantitatively is possible for wildlife risk assessment (e.g., application of CCME tissue guidelines for TEQs).	It is recommended that the HC-2014-019 comment be taken into account in the risk assessment. HC is available to discuss/review the approach at custodians' request. As per Health Canada Part II-TRVs (2010), dioxin-like PCBs are to be evaluated with dioxins as non-carcinogens, using appropriate toxic equivalence factors (TEFs) (see Table 8 of HC Part I-PQRA (2012)) and HC tolerable daily intake for polychlorinated dibenzo-*p*-dioxins/ polychlorinated dibenzofurans (PCDDs/PCDFs). Based on the literature available at

	the potential implications of this data gap should be considered and discussed in the risk assessment. If any future sediment sampling is planned for the lower KIH, consideration should be given to analyzing a subset of samples for dioxin-like PCB congeners, if warranted.		that time (2010), a threshold was expected for the carcinogenic effects of dioxins and dioxin-like PCBs, and a developmental endpoint was identified as a more sensitive endpoint than carcinogenicity (i.e. a higher dose is required to induce cancer than to induce developmental effects in the offspring). Therefore the TRV for dioxins, which is based on developmental effects, would also be protective against carcinogenic effects and appropriate for assessment of typical, low dose exposure. However, recently, the International Agency for Research on Cancer (IARC) reassessed the carcinogenicity of dioxin-like PCBs and dioxins; these substances were upgraded to Group I, known carcinogens. Therefore, recent alternate TRVs (e.g. slope factors) from another regulatory agency, if available, could be used <u>in addition to</u> the HC TRVs to also address the carcinogenic effects of dioxins and dioxin-like PCBs, with appropriate scientific rationale.

HC-2014-020	[Chapter IV - Defining Exposure Point Concentrations] • Hg in fish: Map III-9 seems to show the highest concentrations of Hg in juvenile yellow perch in the area adjacent to the Kingston rowing club, which is within the area of highest contaminant concentrations. Is it possible that fish within the areas of the harbour with highest Hg concentrations in sediments may have higher concentrations of Hg in tissue? If this is the case, and if it is possible that some people may primarily fish within this area, the use of the 95% UCLM for all fish tissue from the inner harbour may underestimate risks for some receptors.	Category 2 - This issue should be discussed in the context of defining management areas. There are several interrelated issues including the degree to which fish collections may reflect localized contamination, the degree to which the fish foraging patterns would smooth out such differences over time, and whether human use patterns would smooth out concentration differences.	Satisfactory response. No further comment.
HC-2014-021	[Chapter IV - Defining Exposure Point Concentrations] • Fish data were not separated by species. If some people may have a preference for a particular species they may consume only one species rather than an average of all species. The report does not include summary statistics for individual species. Therefore, it is not clear whether contaminant concentrations in tissue of any one species may be significantly higher than others. The potential for higher risks associated with selective consumption of the species with the highest concentrations (rather than equal consumption of all species) may	Category 2 - It is common in HHRAs to make simplifying assumptions regarding the dietary preferences of recreational fishers, either through use of an indicator representative species (or combination of species), or through the assumption that measured concentrations in all harvested fish are representative of typical exposure. In this site context, it difficult to define any specific scenario as being optimal. We would like to liaise with Expert Support for guidance on how to incorporate the variations in fish concentration data without making unrealistic or overly conservative assumptions for species	No further comment. HC is available to discuss/review the approach at custodians' request.

	need to be explored if it has not already been considered.	preference.	
HC-2014-022	[Chapter IV - Surface Water Data] • Maps showing surface water sampling locations are not provided in the report (references are provided to other reports where they can be found). Therefore, we could not determine where samples were collected or the surficial sampling program covered sufficient and appropriate areas of the KIH.	Category 4 or 5 - Comment relates to RMC-ESG deliverable; this remains as an uncertainty.	To facilitate peer review and verification of assumptions, maps depicting all surface water sampling locations should be included in the upcoming risk assessment deliverables (or should be provided to ES) as it is helpful in demonstrating or determining if the sampling plan has been adequate to reflect the distribution of chemicals across the site. It could also be important for health risk communication purposes to have a "stand alone" document that includes all pertinent data, assumptions, maps, etc.
HC-2014-023	[Chapter IV - Surface Water Data] • Surface water data is presented only for a subset of the inorganic COPCs (Table IV-8). In particular, data for mercury, antimony or arsenic were not presented in Table IV-8 and it is not clear whether they were analyzed in surface water. If they were analyzed, it is not clear why they are not included in Table IV-8 and the interpretation of surface water data. If they were not analyzed, it is not clear why.	Category 5 - We cannot address this issue without provision of surface water chemistry data from RMC-ESG (assuming that such data exist). Although it is likely that other risk pathways (sediment and dietary exposure) are more important for these parameters, the lack of clear water column screening remains as an uncertainty.	It is recommended that all relevant data, assumptions, etc. regarding surface water be provided, to facilitate peer review and verification of assumptions. It could also be important for health risk communication purposes to have a "stand alone" document that includes all pertinent data, assumptions, etc.

HC-2014-024	[Chapter IV - Surface Water Data] • Surface water samples were analyzed for both total and dissolved metals. The maximum total metals concentrations for lead, zinc and chromium were higher than Ontario Drinking Water standards and Canadian drinking water quality guidelines (CDWAG) (lead and chromium exceeded the Canadian drinking water quality guidelines by several orders of magnitude); however, maximum dissolved concentrations were below both the Ontario standards and the CDWAG. The report indicates that because the dissolved phase constituents were below guidelines/standards and because exposure to suspended solids is evaluated separately, exposure to COPCs in surface water is not considered as a pathway. It is reasonable to evaluate human exposure to suspended sediments separately as people would be expected to disturb the sediments while wading/swimming in shallow water and be exposed to a higher suspended sediment concentration than that measured in surface water samples (which are typically collected in a manner that would minimize the amount of suspended solids in the sample). However, it may also be useful to evaluate risks associated with consumption of surface water during recreation based on	Category 2 - We agree that comparisons of water concentration data should be made to Canadian drinking water quality guidelines using the total concentrations (not dissolved). We will reassess the screening procedure on this basis. With respect to the the calculation of dose in the HHRA, there are multiple choices available for breaking down the total xposure (e.g., suspended sediment combined with water, or separated out as a distinct exposure medium). What is most important is that the parameters assigned to these media (ingestion rates, and concentration estimates) be reasonably reflective of the receptor scenario of interest. We would like to consult with Health Canada on some of the ingestion rates, including incidental sediment ingestion and water ingestion, as the tabulated values in Table IV-13 appear over-conservative.	Satisfactory response. No further comment. At custodians' request, HC could be consulted about ingestion rates.

	total COPC concentrations in surface water as a check for comparison with the estimates based on predicted exposure to suspended sediments.		
HC-2014-025	[Chapter IV - Surface Water Data] • It is not clear whether the reference data for surface water are for total or dissolved constituents. Therefore, it is not clear how the data from KIH compare with the reference data. With the exception of zinc, the maximum concentrations of dissolved data are very similar to those for the reference site for each of the parameters shown on Table IV-8.	Category 5 - Will be addressed in upcoming risk refinement, provided that RMC-ESG can provide assistance in determining units for these data.	Satisfactory response. No further comment.
HC-2014-026	[Chapter IV - Exposure Media] • The report states that there are no beaches or formal bathing areas in the KIH and that people would only be exposed to sediments that are submerged under water. Transport Canada and Parks Canada may wish to confirm that there are no beach-like areas within their water lots and that water level fluctuations do not occur that would expose the contaminated sediments resulting in exposure similar to that in the tidal flat or on a beach.	Category 3 - Requires liaison with Expert Support, and perhaps other parties. The distinction between permanently wetted sediments and those that may be exposed (dry) intermittently along the shoreline has implications for several HHRA parameters, particularly dermal absorption. One approach would be to discuss potential beach formation in the uncertainty assessment vis-à-vis future exposure scenarios and level of conservatism. Also can confirm with Parks Canada and Transport Canada what is known about current human use/access or future scenarios. It appears that dry contact with sediments was not included in the	If beach-like conditions can or could exist, HC recommends that potential health risks associated with these specific areas be evaluated, if possible (not just discussed in the uncertainty section).

		RMC-ESG assessment (whereas wet contact with submerged sediments was); our approach for the risk refinement will be to confirm the assumptions, determine if beach like conditions can or could exist, and discuss implications in uncertainty assessment.	
HC-2014-027	[Chapter IV - Exposure Media] • In their response to Health Canada comments on a previous version of Chapter IV (dated November 5, 2010 and included in Appendix M of the report) Environmental Sciences Group (ESG) notes in comment 16 that "potential direct exposures to bulk dry sediments (such as exposures at a beach) are included in the risk assessment". As noted above, this type of exposure was not included in the risk assessment as there are reportedly no areas of exposed sediments in the lower KIH.	Category 1b - Agree that statement is confusing; will confirm if they are or are not included and explain.	See HC-2014-026 response.
HC-2014-028	[Chapter IV - Exposure Duration and Amortization] • The exposure scenario evaluated is for a person visiting the KIH daily for the months of July and August (for a total of 61 days). It is not clear why receptors would not be expected to visit the site in June or September. Also, the assumption of daily exposure during warmer months may need to be revisited. It appears that there may be residential areas	Category 2 - We will recommend adjusting the amortization for non-carcinogens (longer than 2 months) but also reducing the frequency of site use (less than daily) – the overall risk is a balance between these considerations. Specification of a single scenario that is considered appropriately protective of a population is challenging, particularly when usage patterns may change with foreshore redevelopment.	Satisfactory response. No further comment.

	in close proximity to the western shore of the KIH and residential developments are reportedly planned for the undeveloped portions of the western shore. However, the current physical setting does not reportedly include beaches or other areas that would encourage frequent, repeated wading and swimming.		
HC-2014-029	[Chapter IV - Exposure Duration and Amortization] • Exposure Amortization: Direct contact exposure was assumed to occur daily for 61 days during July and August. This exposure period was amortized over the entire year to estimate exposure. Please note that exposure amortization should be completed on a chemical specific basis with sufficient rationale. In this case, we recommend that the exposure for non-carcinogens be amortized only over the period during which exposure may occur (in this case July and August), unless rationale can be provided for an alternate approach. As noted in the previous comment, the assumption of daily exposure during the entire exposure period could be revisited to evaluate whether it would be reasonable or overly conservative.	Category 2 - See response HC-2014-028 above – similarly, an assumption of more months per year, but with fewer visits per month may be appropriate.	Satisfactory response. No further comment.
HC-2014-030	[Chapter IV - Exposure Duration and Amortization] • Fish consumption rates	Category 2 - Similar to responses HC-2014-028 and -029 above, it is challenging	The significance of the exposure amortization inherent in developing

	were developed based on information from the OMOE (2006) document 2003 Guide to Eating Ontario Sport Fish Questionnaire which is relevant for fish consumption in the Great Lakes. The meal size of 236 g/meal and the consumption frequency of 39 meals/year were used to derive an average daily consumption rate of 24.9 g/day. This results in a significant amortization of exposure to COPCs in fish tissue. Also, it is not clear whether respondents of the OMOE Sport Fish Questionnaire consumed the 39 meals throughout the year (e.g., some fish were frozen for future consumption) or whether consumption was concentrated primarily within a limited fishing season. We recommend that exposure amortization be completed on a chemical and site-specific basis with supporting scientific rationale. The significance of the exposure amortization inherent in developing the average daily consumption rate should be discussed in the risk assessment. If further work is to be done to refine risk estimates for the lower KIH, we recommend contacting OMOE for further guidance on evaluating exposure to COPCs through consumption of impacted sport fish.	to provide exposure amortization "on a chemical and site-specific basis with supporting scientific rationale." The scenario provided is simplified given the lack of site-speciifc information, and it is likely that a scenario of more months per year (i.e., longer fishing and consumption season) is reasonable. However, this begs the question of whether the number of meals per month would also need to be adjusted to compensate. Given that previous advice from Health Canada on earlier RMC-ESG documentation resulted in reduced ingestion rates, it is not clear whether Health Canada is concerned about the specific details of rationale/methods, or with the final tissue ingestion rate, or both.	the average daily consumption rate should be discussed in the risk assessment. This could include a discussion of the uncertainty related to how dose averaging conducted might impact on the risk estimation, assuming various potential fish consumption scenarios. Additionally, OMOECC could be contacted for their guidance on evaluating exposure to COPCs through consumption of impacted sport fish in the Kingston Inner Harbour (since their data forms the basis of the fish consumption rates developed).
HC-2014-031	[Chapter IV - Exposure Parameters] • Dermal Adherence: Dermal adherence	Category 2 - We agree that the dermal adherence factors require careful	No further comment.

	factors for sediments reported by Shoaf et al (2005) were used to evaluate exposure to bedded sediments submerged under water and soil dermal adherence factors from Health Canada PQRA Part I (2012) were used to evaluate exposure to suspended sediments. Please note that there is significant uncertainty associated with the use of the Shoaf et al (2005) dermal adherence factors to estimate dermal exposure to bedded sediments submerged under water. The Shoaf et al (2005) values were estimated based on a study of children playing in a tidal flat comprised of primarily medium sand with an organic carbon content on the order of 1% to 2%. The children in the study were in contact with both submerged (including bedded and suspended) and exposed sediment and the bulk of the adhered sediments is presumably from contact with the exposed sediments rather than the submerged sediments. The exposure scenario evaluated for the KIH involves people playing in shallow water where they are exposed only to submerged (bedded and suspended) sediments that are reported to be comprised of primarily silt and clay with a relatively high organic carbon content (greater than 10% in some locations). If people were expected to be in contact with exposed sediments (i.e., not	consideration in recognition of the data sets available and their relevance to the plausible exposure scenarios for KIH. We have summaries of dermal adherence factors, including data from Shoaf, Kissel, and other authors, but the correspondence to a submerged exposure scenario is weak, even before substrate differences are taken into account. We agree with Expert Support that the existing dermal adherence factors likely overestimate adherence for both bedded and suspended sediments in water, but require guidance for making more realistic estimates.	

	submerged under water) along the shoreline of KIH, the adherence values reported by Shoaf et al (2005) would likely underestimate exposure due to the nature of the sediments (very fine grained with high organic carbon content). However, there are reportedly no exposed sediments along the shoreline and the risk assessment evaluates exposure only to bedded sediments submerged under water and suspended sediments in surface water. Submerged and suspended sediment would not be expected to adhere to the same degree as exposed sediment and a significant portion of submerged and suspended sediment would be expected to wash off as people exit the water. Overall, both the Shoaf et al (2005) dermal adherence factors and the Health Canada (2012) soil dermal adherence factors are expected to overestimate dermal adherence for people playing in the water in KIH. Given that the dermal pathway is a significant contributor and/or driver of risk for most COPCs, consideration should be given to refining the dermal exposure estimates. We are not aware of any published dermal adherence factors relevant to a scenario where people are exposed only to sediments submerged under or suspended in water. Careful consideration should be given to selecting		

	adherence factors for this scenario. Also, if dermal exposure is re-evaluated, one potential approach would be to use one set of dermal adherence factors to estimate combined adherence of both bedded sediments submerged under water and suspended sediments in water, rather than considering them separately and adding the exposures. This may be reasonable since exposure to bedded and suspended sediments in water would generally occur simultaneously for receptors playing in shallow water along the shoreline and the existing dermal adherence factors likely overestimate adherence for both bedded and suspended sediments in water.		
HC-2014-032	[Chapter IV - Exposure Parameters] • No rationale was provided for the use of the Health Canada (2012) soil dermal adherence factor for evaluating exposure to suspended sediments. Also, it is not clear why the Shoaf et al (2005) values were used for hands and feet but the soil values from the PQRA were used for arms and legs as Shoaf et al (2005) report values for arms and for legs. In any subsequent analysis of dermal exposure, sufficient rationale should be provided for the selected dermal adherence factors.	Category 1b - See response to HC-2014-031, above. Once we sort out the exposure factors above, the specific concerns raised in this comment can be addressed, and rationale provided.	Satisfactory response. No further comment.
HC-2014-033	[Chapter IV - Exposure Parameters] •	Category 1b- In the absence of an official	Satisfactory response, however,

	for publication. Rates were developed for hand-to-mouth contact with exposed sediments that are notsubmerged under water (e.g., intertidal sediments or beach sediments) and for incidental ingestion of suspended sediments in surface water. The proposed rates are on the order of 72 mg/hour and 20 mg/hour for children and adults, respectively for incidental ingestion of exposed sediments due to hand-to-mouth contact and 8 mg/hour for all receptors for incidental ingestion of suspended sediments during in-water recreational activities. Based on the exposure time of 73 minutes/day selected for swimming/shoreline play in KIH for toddlers and adults, these rates would correspond to daily rates of 88 mg/day for toddlers and 24 mg/day for adults for incidental ingestion of exposed sediment via direct contact and 10 mg/day for ingestion of suspended sediments. The total exposure for people visiting the KIH via sediment ingestion is likely highly overestimated as ingestion of bedded sediments submerged under water is expected to be insignificant. If sediment ingestion rates were re-evaluated based only on ingestion of suspended sediments, it is recommended that the values proposed by Wilson and Meridian be considered, rather than the lower suspended sediment		

	Sediment Ingestion rates: The exposure scenario evaluated for the KIH involves a receptor wading and swimming in the near-shore water, where they may be exposed to COPCs in sediments submerged under water, including suspended sediments and bedded sediments. Table IV-13 cites sediment ingestion rates of 200 mg/day for toddlers and 100 mg/day for adults. At the time that the original risk assessment was completed in 2010, these values were recommended by Health Canada as a conservative approximation of sediment ingestion rates for people in contact with exposed sediments (i.e., not submerged under water). Given that people are not expected to be in contact with exposed sediments (e.g., beach sediments), incidental ingestión of sediment would likely occur primarily via incidental ingestion of suspended sediment in surface water while playing in the water. Incidental ingestion of bedded sediments is not expected to be significant. Therefore, it appears that the sediment ingestion rates of 100 mg/day for adults and 200 mg/day for children would not be relevant for the site. Please note that Wilson and Meridian (2011 and 2013) developed sediment ingestion rates for Health Canada under contract and a manuscript is currently being developed	Health Canada procedure, we agree that sediment ingestion rates from Wilson and Meridian (2011 and 2013) provide an improved basis for evaluating this pathway, and should replace the over-conservative estimates originally assigned. We propose to use these recent estimates, acknowledging that the hourly estimates require assumptions regarding the number of hours per day spent recreating for each receptor. We propose to apply estimates of hours of exposure per day for toddlers and children (2 hours/day) and teens/adults (4 hours/day).	where possible, assumptions associated with exposure duration and frequency should be documented/justified. Please note that assumptions based on survey of time-activity patterns generally take precedence over assumptions based on regulatory guidance, literature or professional judgment.

	rates (1.5 mg/day) used in the HHRA.		
HC-2014-034	[Chapter IV - Toxicity Reference Values] • The source of the chlordane TRV is not clear.	Category 1a - RMC report Table IV-16 references an oral tolerable daily intake (TDI) of 3.3 x 10^{-5} mg/kg-day for chlordane, and Appendix J (Section C – Chlordane) indicates that this value was obtained from OMOE (2011). OMOE (2011) indicates the TRV is a non-cancer child-specific reference dose (chRD) derived by the California Environmental Protection Agency (CalEPA 2005). The chRD is based on a 1994 study where changes in sex-steroid mediated behaviours were observed in male and female rats following pre- and post-natal exposure to chlordane (Cassidy et al. [1994], as cited in CalEPA 2005). A chlordane dosage of 0.1 mg/kg-day was found to disrupt sex hormone mediated behaviours and was identified as the lowest observed adverse effect level (LOAEL). CalEPA applied a total uncertainty factor of 3,000 (10 for interspecies variability, 10 for human variability and 10 to extrapolate from a LOAEL to a NOAEL, and 3 to account for database deficiencies) to the LOAEL to calculate the cHRD. CalEPA (California Environmental Protection Agency). 2005. Development of Health Criteria for School Site Risk Assessment Pursuant to Health and Safety Code Section 901(g): Child-Specific	Satisfactory response. No further comment.

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		Reference Doses (chRDs) for School Site Risk Assessment - Cadmium, Chlordane, Heptachlor, Heptachlor Epoxide, Methoxychlor, and Nickel. Final Report, December 2005. Integrated Risk Assessment Branch, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. Available at http://oehha.ca.gov/public_info/public/kids/pdf/FinalSchoolReport121205.pdf. OMOE (Ontario Ministry of the Environment). 2011. Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Sites in Ontario. Prepared by Standards Development Branch, OMOE. April 15, 2011. Available at https://www.ontario.ca/environment-and-energy/rationale-development-soil-and-ground-water-standards-use-contaminated-sites.	
HC-2014-035	[Chapter IV - Toxicity Reference Values] • The Contaminated Sites Division (CSD) of Health Canada currently does not endorse a toxicity reference value (TRV) for lead for use in human health risk assessments at contaminated sites. The previous value in Health Canada's guidance - a tolerable daily intake (TDI) of 3.6 µg/kg-day - is no longer recommended	Category 2 - We agree that, pending the review of the toxicology of lead by Health Canada, an alternate for lead should be drawn from another regulatory agency. We are proposing to use an alternative TRV based on a recent SNC-Lavalin assessment of lead toxicity to adults, infants, toddlers, and children. Their assessment resulted in a TRV based on WHO (2011) assessment,	Please note that TRVs developed by other jurisdictions, including values from the WHO JECFA (2011) and EFSA (2013), or in peer reviewed scientific literature may be acceptable with sufficient justification and supporting data. A brief summary of the key health concern(s) associated with

	for use within contaminated site risk assessments. We also no longer recommend the use of the OMOE TDI of 1.85 µg/kg-day. These TDIs were based on a value from JECFA/WHO, which has been withdrawn by JECFA as it was considered that the value was unlikely to be protective of human health (JECFA, 2010). Until the review of the toxicology of lead is completed by Health Canada, it is recommended that qualified risk assessment professionals identify a TRV for lead from another regulatory agency. Alternate TRVs, including values from the California OEHHA (2007; 2009) or JECFA, may be used in quantitative risk assessments at federal contaminated sites, with appropriate scientific rationale.	a conclusion consistent with the withdrawal of the WHO (2010) value by Health Canada.	exposure should be provided within the risk assessment report. The summary should discuss both cancer and non-cancer endpoints, and differentiate effects by exposure route (oral, dermal, inhalation), as appropriate.
HC-2014-036	[Chapter V - Need for Management Actions: Summary of the Main Outcomes from Chapters II, III and IV] • It is noted on page 1-2 that "the toxicity thresholds do not account for possible synergistic effects resulting from the complex mixture of contaminants in the APEC" and that the assessed risk may therefore be "greatly underestimated". The term "greatly" is not qualified with supporting text and although this statement on possible synergistic effects appears to be related to assessed ecological risk (i.e. to the brown bullhead	Category 4 - This comment, which we agree with, appears to relate to narrative that is specific to the RMC-ESG deliverable. However, the broader implications of the comment link to the degree of certainty we can have that remediation drivers have been appropriately identified. Given the challenges in evaluating interaction effects for both human health and ecological receptors, this issue is best dealt with in the uncertainty analysis..	The HC-2014-036 comment still stands for the RMC-ESG report or for the upcoming risk refinement report.

	fish), it undermines one of the report's major messages (i.e. that it is now time for management actions) since the management actions may not mitigate the currently unknown risks to receptors from chemical mixtures. Furthermore, there does not seem to be any initiative to assess possible synergistic effects of the complex chemical mixture on health risk to humans. Given the complexity of the chemical mixture, the challenges inherent to managing any assessed risk (likely a combination of management actions) and the goals of risk mitigation (i.e. to reduce risk to receptors), assessment of chemical mixtures or perhaps further consideration in an uncertainty analysis, may be considered.		
HC-2014-037	[Chapter V - The Framework for Addressing and Managing Contaminated Sites Under the Federal Contaminated Sites Action Plan] • There is a footnote on page II-1 that refers to "Section 6.1.1.2 of Treasury Board Guidelines" that not only does not provide a reference, but also selectively and incompletely quotes Treasury Board Policy. The lack of proper reference makes the content difficult to verify by the reader. The text is in fact a slightly refined (text omitted) exact quote of Section 6.1.12 (not	Category 4 - This comment is specific to the RMC-ESG report.	The HC-2014-037 comment still stands for the RMC-ESG report or for the upcoming risk assessment deliverables.

	6.1.1.2, which does not exist) of the Treasury Board (TB) Policy on Management of Real Property (effective November 11, 2006). The most notable omission is the word "federal" that should be present in the sentence, "Management activities (including remediation) must be undertaken to the extent required for current or intended federal use." The other omission from the TB Policy is "...or requirements that may be applicable abroad" in the sentence: "These activities must be guided by standards endorsed by the CCME or similar standards or requirements that may be applicable abroad." It is recommended that any inaccurate interpretations made in the report text as a result of the omissions be corrected.		
HC-2014-038	[Chapter V - The Framework for Addressing and Managing Contaminated Sites Under the Federal Contaminated Sites Action Plan] • On page II-2, it is noted that completion of the ASCS Pre-screening Checklist led to an automatic Class 1 designation for the site and that the worksheets were completed for "comparative purposes". It should be noted that current guidance specifies that "A site scored as Class 1 using only the pre-screening checklist will not be considered	Category 4 - Our scope does not include NCSCS or ASCS classification; however, our scoring at DQRA stage also identified a Class 1 designation.	The HC-2014-038 comment still stands for the RMC-ESG report or for the upcoming risk assessment deliverables.

	eligible for FCSAP R/RM funding without the completion of the remaining NCSCS or ASCS worksheets for eligibility review." Nevertheless, the full scoring completed by ESG ultimately did score the site as Class 1.		
HC-2014-039	[Chapter V - The Framework for Addressing and Managing Contaminated Sites Under the Federal Contaminated Sites Action Plan] • There does not seem to be any justification given on page 11-17 for the statement, "...it is unlikely that [combined sewer overflow] effluent contains high levels of contaminants such as Cr and PCBs..." i.e. there should be justification qualifying why this is unlikely.	Category 4 - This comment is specific to the RMC-ESG report.	The HC-2014-039 comment still stands for the RMC-ESG report or for the upcoming risk assessment deliverables.
HC-2014-040	[Chapter V - Analysis of Management Options] • On page III-6, the dredging management option is selected as the preferred remediation strategy in part due to its "likely effectiveness"; however, the statement is not supplemented by supporting documentation that demonstrates its effectiveness for the site in question. Furthermore, the statement on page III-7 that "dredging does not require long-term maintenance or post-remediation performance monitoring" can be misleading since performance	Category 4 - This comment is specific to the RMC-ESG report.	The HC-2014-040 comment still stands for the RMC-ESG report or for the upcoming risk assessment deliverables.

	effectiveness would need to be monitored and thus demonstrated, as is indicated in Table V-I, page II-7, Risk Management Principle #11.		
HC-2014-041	[Chapter V - Analysis of Management Options] • There is little discussion regarding prevention of recontamination of any dredged areas by adjacent contaminated sediments. Accordingly, the management options analysis should have identified mitigation measures to ensure/minimize the dredged areas becoming impacted by adjacent sediment. Furthermore, the analysis of management options only considers the management options in isolation of one another not taking into considerations innovative and integrated solutions. Management options may ultimately involve a combination of the various methods available (no action, institutional controls, monitored natural recovery, capping, dredging, etc.), since the site is complex in its contaminant profile and physical/chemical/biological processes and issues and goals are geographically unique.	Category 4 - This comment is specific to the RMC-ESG report.	The HC-2014-041 comment still stands for the RMC-ESG report or for the upcoming risk assessment deliverables.
HC-2014-042	[Chapter V - Sediment Management Goals for the KIH] • The spatially weighted average concentration (SWAC) methodology and, in particular, the procedure for calculating the area of the	Category 1b - In the risk refinement, exposure point estimates (and supporting statistics) with be provided for each management zone.	Satisfactory response. No further comment.

	harbour "requiring management" for each COC, are not explained in clear enough detail for the reader and there is a lack of supporting calculations. Also, the discussion regarding SWACs for various COCs seems out of place on page IV-11, as it appears in a section dedicated to deriving Sediment Quality Objectives (SeQOs) for PCBs.		
HC-2014-043	[Chapter V - Sediment Management Goals for the KIH] • The rationale for the choice of the boundaries of the PAH management zone lacks clarity. In fact, there doesn't seem to be a complete rationale justifying the footprint of the ultimately proposed management areas. Also, the ESG overall proposed management area excludes most of the area, i.e. in and around Anglin Bay, that Golder (2012) had previously identified as being the best candidate for active management based on evidence gathered by them to-date.	Category 1b - We agree with the comment. The boundaries for the PAH management zone may have been defined based on an acknowledgement that HQs could not be reduced to below one without identification of a large volume of sediment. The risk refinement will contain several changes to the exposure parameters that will influence HQs (on an area-specific basis).	Satisfactory response. No further comment.
HC-2014-044	[Chapter V - Sediment Management Goals for the KIH] • Given the spatial extent and levels of contamination in sediments (Maps II-6 to 11-16) adjacent to the SWAC zones shown in Maps V-I to V-8 (and the proposed PAH shoreline management area), it would appear likely that contaminant levels in dredged zones	Category 4 - This comment relates to the proposed sediment stability study and to evaluation of reliability and effectiveness of dredging, both are which are important but beyond our current scope.	It is recommended that the HC-2014-044 comment be taken into account in further studies/reports.

	would gradually increase above the proposed SeQOs through sediment movement due to waves, wind, propeller wash, etc. Furthermore, the sediment movement patterns appear to be poorly understood and study of sediment movement can be considered a prerequisite to finalization and implementation of the ultimate management strategies. It is not understood how long the contaminant levels in the proposed management zone (Map V-8) will remain within the SeQOs and also how the risk would change as contaminant levels gradually rise above those SeQOs. Also, there is little or no sediment data available for the sediments in the marina area and the data along the shoreline north of the marina is very sparse. If TC was to consider doing any additional sediment sampling, these areas would warrant further investigation. The lack of data in that area is also of concern as this elevated contamination is outside the proposed management area and potential human health risks may not be properly and completely assessed or mitigated. It would seem appropriate that one of the goals in any remedial strategy would be that a managed or dredged area does not become recontaminated, such that future		

	site use does not result in new risks to human health.		
HC-2014-045	[Chapter V - Sediment Management Goals for the KIH] • It is not clear whether the exposure point concentrations (EPCs) were derived from sediment data for all depths or whether only certain depths were considered. ESG notes that two samples at depth with exceptionally high PAH concentrations in one area and two samples at depth with exceptionally high antimony concentrations in another area were not included when the EPCs were developed. It would thus appear that all data were included regardless of depth (except the aforementioned four samples). If TC were to develop a revised HHRA, they could consider whether they can define a depth at which exposure would no longer be expected (i.e., people and aquatic organisms would not come into contact with these sediments as they are buried and are at a depth where they are not expected to be exposed as a result of regular activities and conditions in the harbour). They could consider excluding the data from below this depth from the statistics used to define EPCs. Any contamination at depth that is excluded from the risk assessment would need to be risk managed and it would need to be ensured to the extent practicable that the sediments	Category 1b - Agree with comment. Per the advice, for risk assessment, we will define a depth at which exposure would not be expected, but will retain understanding of contamination at depth as part of remedial options evaluation.	Satisfactory response. No further comment.

	remain buried. If it is later proposed that they be exposed (e.g., due to dredging), they would need to be incorporated into the risk assessment and/or managed appropriately.		
HC-2014-046	[Chapter V - Sediment Management Goals for the KIH] • Although responses to reviewer comments (Appendix M) allude to some of the changes made in the revised report, it would be helpful if the report author could provide additional supporting documentation for those changes and point out/justify any changes made that weren't addressed in the documented responses to reviewer comments.	Category 4 - Comment relates to RMC-ESG deliverable only.	No further comment.
HC-2014-047	[Chapter V - Residual Risk and Uncertainty Analyses] • As noted in this review, there are additional uncertainties that need to be considered that are not considered here (discussed elsewhere in this review).	Category 1b - To be addressed in uncertainty analysis.	Satisfactory response. No further comment.
HC-2014-048	[Chapter V - Considerations for RAP Design] • Ongoing site and risk assessment studies will be required prior to development and implementation of a remedial action plan (RAP). The text is correct to note that uncertainties are present and need to be addressed.	Category 4 - We agree.	No further comment.

HC-2014-049	[Chapter V - Conclusions and Recommendations] • As noted earlier, contrary to the assertions in the ESG report (reiterated in the Conclusions and Recommendations), based on this review and the review completed by Golder, there appears to be considerable work remaining before developing and implementing a remedial action plan for KIH.	Category 4 - We agree.	No further comment.
HC-2014-050	[Chapter V - References] • The reference section does not include the required reference to the Treasury Board Policy on Management of Real Property	Category 4 - Comment relates to RMC-ESG deliverable only.	No further comment.
HC-2014-051	[Chapter V – Minor Comments] • The text on page 11-19 notes that among the 4 SARA species of turtles, some have "endangered" status; however, none of the 4 turtles listed in Table V-3 on page 11-20 are noted to be endangered.	Category 1b - Will be clarified as part of the assessment of listed and endangered species.	Satisfactory comment. No further comment.
HC-2014-052	[Chapter V – Minor Comments] • The sediment stratigraphy of selected cores collected in the KIH is shown in figure V-l (not Figure V2 as noted in the text on page III-8).	Category 4 - Comment relates to RMC-ESG deliverable only.	No further comment.
HC-2014-053	[Chapter V – Minor Comments] • It appears that, for clarity, the title of map V2 should be "Arsenic Map of 6 ppm of surface sediments in KIH": the current title	Category 4 - Comment relates to RMC-ESG deliverable only.	No further comment.

	excludes "ppm".		
HC-2014-054	[ESG Report Format and Geographical References] • The report is lengthy (1027 PDF pages) but does not provide PDF bookmarked sections or an overall table of contents. This makes the report extremely difficult to navigate and to find supporting tables, calculations and figures. Thus, it is suggested that these and other changes noted herein would improve the overall readability and accessibility of the report.	Category 4 - Comment relates to RMC-ESG deliverable only.	No further comment.
HC-2014-055	[ESG Report Format and Geographical References] • Another notable challenge with navigating the report stems from the fact that KIH is defined in the report Executive Summary as the stretch of the Cataraqui River between the 401 and the Lasalle Causeway. It would perhaps be more practical to define the KIH as the stretch of the Cataraqui River between Belle Island and the Lasalle Causeway since this appears to be a conventional reference and the bulk of the study area figures are labelled that way and only show that stretch. Furthermore, the area contains the federal water lots in question and the numerous unique and geographically separate zones of contamination. The lengthy stretch north of Belle Island to the 401 is spatially	Category 2 - Completely agree that we must be clear in defining the studied area, or sub-areas within. Would like to discuss with FCSAP to make sure that terminology is clear and broadly supported.	Satisfactory comment. No further comment. HC is available to discuss/review the proposed approach at custodians' request.

	extensive, is labelled in part as the Rideau Canal (Figures 1-1 and I-2 in Chapter 1), and is considered to be uncontaminated and is not characterized in the report to the same extent (serves as background data for comparison with contaminated areas south of Belle Island).		
HC-2014-056	[ESG Report Format and Geographical References] • As noted in Golder's review, the southern area (between Belle Island and the Lasalle Causeway) is treated in the ESG report as a single exposure area or APEC, and the numerous contaminated zones that are spatially-separated and unique in their contamination issues are grouped together as the "southwestern KIH". It would be easier to locate/visualize specific issues/areas if the numerous unique contaminated zones were identified more frequently in the text in terms of their geographical (northwest, southwest, etc.) localization within this exposure area/APEC. Instead, the current text refers regularly to contamination by families of contaminants (i.e. metals, PAHs, etc.) and specific contaminants (chromium, mercury, etc.), in the "southwestern" KIH (i.e. southwest of Belle Island). This is very imprecise/ambiguous in geographical terms, given the numerous unique contaminated zones in the exposure	Category 1b - Our specification of new management areas, along with resolution of issue HC-2014-055 should take care of this.	Satisfactory comment. No further comment.

	area/APEC, including in its southwest portion.		
HC-2014-057	The Golder memorandum is well written and is a good high level synopsis/analysis of the final ESG report and HC ES provides the following general comments.	Category 1a - Thank you; no response required.	No further comment.
HC-2014-058	With reference to the Golder (2013) source investigation for the southwest TC water lot, Golder notes that recent findings have shown that in many areas, offshore PAH concentrations exceed those along the shoreline. Furthermore, it is noted that coal tar has historically been observed in core samples in the vicinity of Anglin Bay and that historical deposition of coal tar may be a significant source of PAH contamination within Anglin Bay sediments. This is important when considering management options related to PAHs and their impact on human health.	Category 1b - Agree with comment. Concentrations of PAHs in near-surface sediments will be addressed in upcoming risk refinement, both in terms of spatial distribution and associated risks to all receptor groups. Additionally, contamination at depth should be considered in future remedial options evaluation.	Satisfactory response. No further comment.
HC-2014-059	As noted by Golder, background exposure to PCBs does not appear to have been considered in the human health risk assessment, in identifying special management areas or in the development of sediment quality objectives. However, a hazard quotient of 1 was applied rather than the Health Canada default of 0.2 for risk estimates developed without consideration of background. The Health	Category 2 - Rather than apply the Health Canada default of 0.2 for risk estimates developed without consideration of background, it may be feasible to adjust exposure to include background sources. Because much of PCB exposure to urban residents in the Great Lakes comes through dietary consumption, use of a baseline ingestion for a typical resident could be added to the site-specific exposure from	Satisfactory response. Please ensure to provide adequate, scientifically-based rationale and referenced data for any assumptions made, should a threshold hazard quotient different than 0.2 be used for PCBs.

	Canada default HQ of 0.2 is typically applied where background (off-site) exposures (e.g., from food, consumer products, water and air) have not been considered in order to minimize the chance that total exposure (site + background) does not exceed the tolerable daily intake. HC concurs that further justification should be provided for the use of a threshold hazard quotient other than 0.2 where background exposure is not considered.	recreational exposure to KIH. This approach may yield a less conservative but more relevant estimate to use of default of 0.2.	
HC-2014-060	Golder points out a number of areas where they concur with ESG, as well as several areas that they do not. Golder's review brings into question some of the methodologies employed by ESG in assessing health risks, and the conclusions and proposed management decisions drawn from obtained results. In this regard, our HC ES review of the ESG report is in line with the Golder review in that there still appears to be a lot of uncertainty with regards to the estimated level of risk to human receptors and what possible mitigations could be implemented to manage those risks to human health. HC ES concurs with Golder that additional work is needed with regards to assessing and managing contamination within the KIH in order to address those uncertainties	Category 1b - Thank you; no response required.	No further comment.

	and thereby more accurately characterize the risks to human health associated with KIH. To this end the ESG report is a valuable body of data that can potentially support additional assessment and management work on-site.		

Health Canada Santé Canada

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August 19, 2015

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Dear Brent,

Subject: HC Comments on Draft Human Health Risk Refinement Model for Kingston Inner Harbour, Kingston, Ontario (Custodians: Transport Canada and Parks Canada)

Health Canada reviewed draft dose calculations for two contaminants of potential concern (COPCs) in the Excel workbook titled "*DRAFT Human Health Model Kingston Inner Harbour – Risk Refinement*," dated August 10, 2015 and authored by Golder Associates Ltd. Based on the email received by Health Canada from Golder Associates Ltd. on August 10, 2015, it is our understanding that these sample calculations were submitted for an initial round of review prior to submission of the full risk refinement deliverable for Expert Support review at a later point. Our comments are attached.

Please contact the undersigned if you have any questions with respect to these comments.

Sincerely,

Adam Griffiths

Adam Griffiths, M.Sc.
Health Risk Assessment & Toxicology Specialist

cc: Javier Banuelos, Public Works and Government Services Canada
Sue-Jin An, Public Works and Government Services Canada
Lynn Kumita, Health Canada
Vanessa Lyon, Health Canada
Christine Levicki, Health Canada

Health Canada / Santé Canada

MEMO: Health Canada Comments on Draft Human Health Model Kingston Inner Harbour – Risk Refinement, Kingston, Ontario

Report title: Draft Human Health Model Kingston Inner Harbour – Risk Refinement
File name: Draft KIH HH risk refinement model 10Aug2015.xlsx
Report author: Golder Associates Ltd.
Report date: August 10, 2015
Reviewed by: Adam Griffiths, Contaminated Sites Program (Ontario Region), Health Canada
Date reviewed: August 19, 2015

Thank you for the opportunity to review and provide comment on the Draft Human Health Model Kingston Inner Harbour – Risk Refinement. The focus of this review was on the proposed equations and general input parameters to be used for calculating human exposures/risks at this site and to ensure that previous discussions between Golder Associates Ltd. and Health Canada (via email exchange and teleconference calls) on the risk refinement for this site have been appropriately captured. However, please note that Health Canada has not conducted a thorough validation of all calculations and data presented, and it falls to the consultant to ensure their accuracy and validity.

Health Canada provides these comments as per our role as an Expert Support department for the Federal Contaminated Sites Action Plan. These comments are in no way to be interpreted as any type of approval, authorization, or release from requirements to comply with federal statutes and regulations.

Major Comments

1. Tab "Exposure Pathways":
   - In Column D "Refinements Made" and row 17 "Incidental ingestion of surface water," a statement is made that risk estimates will be summed for the relevant pathways at this site. As part of this summation, it is indicated that the "incidental ingestion of suspended sediments" pathway would be included in the sum to account for incidental water intake rather than inclusion of the "incidental ingestion of total concentrations of COPCs in surface water" pathway. The rationale provided is that the incidental ingestion of suspended sediments would provide a more conservative risk estimate than that of total concentrations in surface water. Please note that the surface water incidental ingestion rate of 11.2 mL/hr from Dorevitch et al. (2011) and the calculated suspended sediment ingestion rate of 7.7 mg/hr in Wilson et al. (2015) are intended for near-shore activities where playing, wading and splashing may occur. However, as indicated in Wilson et al. (2015), for larger sites where swimming in deeper waters may occur, the greater incidental surface water ingestion rates from Dufour et al. (2006) may be more appropriate than those from Dorevitch et al. (2011). Wilson et al. (2015) also indicates that measurements of total concentrations of COPCs in surface water may be useful in such deeper water scenarios so as to eliminate the need for assuming a suspended sediment concentration. Please consider whether two incidental

water ingestion scenarios may thus be appropriate for this site, namely the current suspended sediment ingestion scenario to reflect near-shore exposures, and a second scenario to reflect swimming in deeper waters based on total COPC concentrations and an incidental surface water ingestion rate appropriate for swimming.

2. Tab "COPC Concentrations":
    - Footnote 2) indicates that for surface water, where a parameter was not detected, half the detection limit was used as the exposure point concentration (EPC). However, footnote 3) indicates that for fish tissue data, where a parameter was not detected, a full detection limit was used as the EPC (except in the case of arsenic where half the detection limit was used). Please provide a rationale to explain why half the detection limit would be used for one environmental medium (or COPC) and a full detection limit for another.

3. Tab "Dose Equations":
    - For the "Dermal Contact of Feet with Submerged Bedded Sediment" equation, a "D1" exposure term to account for hours per day that sediment is adhered to the feet is included (i.e., 2/24). The introductory explanation at the top of this worksheet indicates that the "dermal absorption from contaminated sediment" equation was adopted from the "dermal absorption from contaminated soil" equation in Health Canada's Part I Preliminary Quantitative Risk Assessment (PQRA) guidance (Health Canada 2012). Please note that the "dermal absorption from contaminated soil" equation in Health Canada (2012) does not include a D1 term for dermal contact (i.e., dose is not exposure time-dependent on a day of exposure for this pathway). A rationale should be provided to support a 2/24 "dilution factor" for dermal contact with sediment exposures.
    - For the dose equations for estimating exposures from sediment and surface water direct contact pathways (i.e., incidental ingestion and dermal contact), although the equations indicate that chemical-specific consideration for dose averaging will be made for the "weeks per year" exposure term for non-carcinogens, the "days per week" exposure term has no such stipulation. The Excel workbook indicates that sediment and surface water exposures at this site are assumed to occur either once per week (for the North and Central exposure areas) or twice per week (for the South exposure area). As such, use of the "days per week" exposure term would result in significant dose averaging for non-carcinogens (i.e., 1/7 to 2/7). As per earlier Health Canada comments on this site and as per section 4.6.2 of Health Canada Part V Detailed Quantitative Risk Assessment for Chemicals ($DQRA_{CHEM}$) guidance (Health Canada 2010a), dose averaging should be considered on a site- and chemical-specific basis. The anticipated effects of the dose-averaged exposure should remain biologically equivalent to the unadjusted exposure, with such considerations as the: (a) mode-of-action; (b) duration of effects; (c) likelihood of exposures during a sensitive life-stage; and (d) whole-body elimination half-life. Please consider providing site- and chemical-specific rationale for any dose averaging for non-carcinogens at this site for the sediment and surface water direct contact pathways, regardless of how the dose averaging is implemented via the exposure terms used (i.e., hours per day, days per week and/or weeks per year).

4. Tab "Chemical Properties":
    - A footnote to this table indicates that chemical properties, namely the dermal permeability coefficient (Kp), were obtained from the "Part IV: Spreadsheet Tool for Human Health Preliminary Quantitative Risk Assessment," which is cited as "Health Canada (2011)" in this tab. Please note that this spreadsheet model was developed by Meridian Environmental Inc. ("Meridian") in 2011, under contract to Health Canada and in support of its draft PQRA guidance (Health Canada 2009). This model is strictly a spreadsheet-based implementation of the equations, algorithms, default parameters, and other information presented in Health Canada's guidance at the time or as suggested by Health Canada during its development.

      Since the release of this spreadsheet, errors and omissions were noted by, or reported to, Health Canada but that have not been addressed. Further to this, newer guidance published since the creation of this spreadsheet along with more recent versions of Health Canada's guidance documents in the series on Federal Contaminated Site Risk Assessment in Canada (e.g., new TRVs, short-term exposure guidance, etc.) have not been incorporated into this spreadsheet and as such, the spreadsheet no longer reflects current Health Canada guidance. At this time, Health Canada will no longer be supporting the spreadsheet or providing further updates and corrections.

      Meridian, Health Canada, and their respective employees shall not accept any liability for the results or consequences of any actions taken or decisions made based on the use of this spreadsheet model. Use of this spreadsheet model does not in any way relieve the user of responsibility for compliance with all applicable regulatory requirements.

      Health Canada reserves the right to update or modify this spreadsheet model at any time.

5. Tab "TRVs":
    - An oral tolerable daily intake (TDI) of 0.00013 mg/kg-bw per day for "total PCBs" is provided in the table based on Health Canada's Part II Chemical-specific Factors and TRVs guidance (Health Canada 2010b). Please note that this oral TDI applies to the total of non-dioxin-like (i.e., non-coplanar) PCBs; however, for dioxin-like PCBs, Health Canada (2010b) indicates that they should be evaluated with dioxins, using toxic equivalence factors (TEFs) from Health Canada (2012). Please clarify how dioxin-like PCBs will be addressed in the risk refinement deliverable.

6. "Doses and Risks" Tabs:
    - The Excel workbook provides sample exposure and risk calculations for one carcinogen (i.e., arsenic) and one class of non-carcinogens (i.e., PCBs). As such, the approach that will be used to evaluate cumulative risks from multiple substances in the main risk refinement deliverable is not presented. Please ensure that for simultaneous exposures to other multiple non-carcinogenic COPCs, determined to share similar target tissues/organs and/or mechanisms of action, hazard quotients (HQs) should be summed to generate total hazard indices (HIs), as per Health Canada (2012) guidance. In addition, for simultaneous exposures to other

multiple carcinogenic COPCs, determined to share similar target organs, mechanisms of action and/or forms of cancer, please ensure that incremental lifetime cancer risks (ILCRs) are summed to generate total ILCRs (as per Health Canada 2012 guidance).

7. Tab "SUMMARY – Risk Estimates":
   - The cumulative ILCRs calculated for arsenic, based on the summation of total ILCRs for the four age groups considered relevant to this site (i.e., toddlers, children, teenagers and appear to have been calculated without consideration of age-dependent adjustment factors (ADAFs). As a general comment for the coming risk refinement deliverable, for each carcinogenic COPC that will be considered, please ensure to indicate whether the carcinogen is known to act via a mutagenic mode of action or not. For those that are known to do so, please consider using ADAFs presented in Health Canada's interim guidance for short-term exposures to carcinogens (Health Canada 2013) in calculating cumulative ILCRs.

Minor Comments

1. Tab "Exposure Pathways":
   - In Column D "Refinements Made" and row 12 "Incidental ingestion of suspended sediment while swimming," a suspended sediment ingestion rate of "7.7 mg/day" from Wilson et al. (2015) is cited. Please verify the units as the rate presented in Wilson et al. (2015) is 7.7 mg/hr.
   - In Column D "Refinements Made" and row 18 "Dermal contact with surface water (whole body)," it is indicated that World Health Organization guidance will be consulted with respect to water quality guidelines for recreational use. Please note that the Ontario Ministry of the Environment and Climate Change (MOECC) has also published water quality guidelines that include consideration of recreational use of surface water based on public health and aesthetic considerations, namely the Provincial Water Quality Objectives (PWQOs) (MOEE 1994).

2. Tab "Receptor Characteristics":
   - Please verify the "Wilson et al. (2014)" reference cited for the suspended sediment ingestion rate and the incidental surface water ingestion rate used. The reference appears to actually be for Wilson et al. (2015).

References

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[Meridian] Meridian Environmental Inc. 2011. Federal Contaminated Site Risk Assessment in Canada, Spreadsheet Tool for Human Health Preliminary Quantitative Risk Assessment (PQRA). Spreadsheet designed and programmed by: Meridian Environmental Inc., under contract to: Health Canada. Version: July 13, 2011.

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