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Human Health and Ecological Risk Assessment Canadian Coast Guard Southside Base, Berth 28 Southside Road St. John's, NL

Prepared for

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Final Report

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EXECUTIVE SUMMARY

Stantec Consulting Ltd. (Stantec) was retained by Public Works and Government Services Canada (PWGSC) on behalf of Fisheries and Oceans Canada/Canadian Coast Guard to conduct a human health and ecological risk assessment (HHERA) at the Canadian Coast Guard (CCG) Southside Base, Berth 28 (the Site) located off Southside Road in St. John's, Newfoundland and Labrador (NL). The purpose of this HHERA is to determine whether chemical concentrations identified at the Site pose unacceptable risk to human (*e.g.,* Site Workers and Visitors) or ecological (*e.g.,* birds, mammals, plants) receptors given the current and future land use.

The current land use at the Site is industrial land use. However, this HHRA will use commercial land use (no day care) since it is assumed that a slab-on-grade multi-story office tower with a footprint of approximately 1,850 m^2 will be built on the Site.

The purpose of this Human Health Risk Assessment (HHRA) is to evaluate the potential that human receptors may experience toxicologically induced changes in health as a result of exposure to COPCs found at the Site. In the HHRA, benzene and PHC fractions (F1 and F2) in soil were carried forward for exposure to indoor air for the Site Worker and Site Visitor; while carcinogenic PAHs and lead in soil were carried forward for direct contact for the Construction worker. The SSTLs calculated for the Site Worker (building occupant) and Site Visitor were greater than the maximum concentration on site with the exception of the PHC fractions (F1 and F2). In addition, soil vapour data was collected as part of the HHRA to further evaluate the potential for vapour intrusion into the proposed site building, and to provide a more realistic estimate of anticipated indoor air concentrations of the COPCs in the proposed site building as a result of subsurface petroleum hydrocarbon impacted soil present on the property. The results of the soil vapour sampling program supported the HHRA findings, and show that unacceptable risk may be present at the site for a Site Worker and Site Visitor (*i.e.,* building occupant) exposed to F1 and F2 PHC fractions and benzene via inhalation of indoor air with the concentrations in soil vapour sample VP04 having predicted HQ/ILCRs greater than the target HQ/ILCR. Based on these results, remediation or risk management measures should be developed to limit the exposure of the Site Worker and Site Visitor to within acceptable limits.

The Construction Worker will be exposed to soil as it is assumed that there will be earthwork activity during the construction of the proposed office building. As a result, the construction worker may be exposed to the lead and PAH concentrations in the soil. However, the SSTLs calculated for the Construction Worker were greater than the EPCs for lead and PAHs. Therefore, the concentrations of lead and PAH in the soil should not result in unacceptable risk. The indoor air pathway is not of concern for the Construction Worker, and as a result the concentrations of benzene and PHC fractions are not considered a concern. In conclusion, no unacceptable risk to the Construction Worker is expected on Site as a result of chemicals in soil.

All chemical concentrations (*i.e.,* PHCs, PAHs, PCBs, and inorganic parameters) in groundwater were within acceptable limits for human health and no unacceptable risk is expected as a result of exposure to groundwater on the Site.

The purpose of this ERA is to evaluate the potential that ecological receptors (*e.g.,* mammals, birds, plants, invertebrates) may experience toxicologically induced changes in ecological health as a result of exposure to COPCs found at the Site. As the Site is completely covered in asphalt and/or the proposed office building, no unacceptable risk to ecological receptors is expected because there is no probable exposure pathway for the ecological receptors to be exposed to the COPCs in the soil and groundwater.

PHC F1, F2, and F3 fraction concentrations on site are greater than the CWS Management Limit Values. Therefore, during the design and construction of the building and associated services, consideration should be given to the physical nature of PHC F1, F2, and F3 on Site.

Based on the findings of the HHRA, there are potential unacceptable risks for the Site Worker and Site Visitor on Site as a result of benzene, F1 and F2 PHC fractions in the soil. An area of approximately 340 m^2 of soil on the site in the vicinity of boreholes BH3 and BH6 is impacted with F1 and F2 PHC fraction concentrations exceeding the toxicological based SSTLs (benzene =2.35; F1 = 474; F2 = 4560) for indoor air. The impacted area is shown on Drawing No. 121412715-EE-03 in Appendix A, and is defined based on field and analytical evidence identified in boreholes BH3 and BH6 during the Stantec Phase II ESA (Stantec, 2013a), as well as analytical results from historical test pits TP106 and TP107 completed by MGI in 2001, as summarized in Stantec's Phase II ESA (2013a). Soil samples with concentrations of petroleum hydrocarbons that exceed the SSTLs in this area were identified at depths ranging from 1.3 m to 3.8 mbgs. Based on the defined area of impacts and identified thickness of impacts (*i.e.,* approximately 2.5 m), the approximate volume of petroleum hydrocarbon impacted soil exceeding SSTLs in this area is 850 m^3.

It should be noted that the F1 and F2 PHC fraction concentrations in BH15 also exceed the toxicological based SSTLs (benzene =2.35 mg/kg; F1 = 474 mg/kg; F2 = 4,560 mg/kg) for indoor air. However, this sampling location is greater than 30 m from the proposed building footprint and is assumed to be covered by an asphalt parking lot. Therefore, the indoor air pathway is not applicable for this sampling location. However, it should be noted that if a building is proposed in the BH15 location, PHC concentrations may need further consideration for the indoor air pathway in this area.

Based on the information provided above, remediation or risk management measures should be developed to limit the exposure of the Site Worker and Site Visitor to within acceptable limits. It should be noted that a Remedial Action Plan has been developed for the Site under a separate cover to address petroleum hydrocarbon impacted soil present at the site exceeding SSTLs.

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1.0 INTRODUCTION

Stantec Consulting Ltd. (Stantec) was retained by Public Works and Government Services Canada (PWGSC) on behalf of Fisheries and Oceans Canada/Canadian Coast Guard to conduct a human health and ecological risk assessment (HHERA) at the Canadian Coast Guard (CCG) Southside Base, Berth 28 (the Site) located off Southside Road in St. John's, Newfoundland and Labrador (Drawing No. 121412715-EE-01 in Appendix A). The purpose of this HHERA is to determine whether chemical concentrations identified at the Site pose unacceptable risk to human (*e.g.,* Site Workers and Visitors) or ecological (*e.g.,* birds, mammals, plants) receptors given the current and future land use. The HHERA uses data collected as part of previous environmental investigations at the Site.

1.1 Human Health and Ecological Risk Assessment Framework

All chemicals (from anthropogenic and natural sources) have the potential to cause toxicological effects. However, the level of effect (*i.e.*, risk) depends on the receptor (*i.e.,* person or wildlife) being exposed, the route and duration of exposure (*e.g.,* oral exposure for chronic durations) and the hazard (*i.e.,* inherent toxicity) of the chemical. If all three components are present (*i.e.,* where the three circles intersect in Figure 1-1), the possibility of a toxicological risk exists. If one or more of these three components are missing, then there would be no unacceptable risk. For example, a receptor could be exposed to a chemical, but if that chemical was present at concentrations below its toxic threshold or exposure limit, then no risk would be expected. Alternatively, a chemical may be present at concentrations above its exposure limit, but if there is no route of exposure for a receptor, then that receptor would not be at risk.

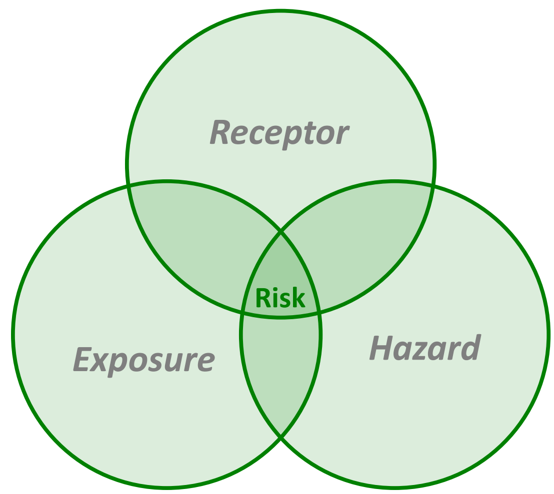

Figure 1-1 Risk Assessment

This HHERA was conducted according to widely accepted risk assessment methodologies and follows guidance published and endorsed by regulatory agencies, including Health Canada (2010a; 2010b; 2010c), the Canadian Council of the Ministers of the Environment (CCME, 1996; 1997), Environment Canada (2012a) and the United States Environmental Protection Agency (U.S. EPA, 1998). The risk assessment framework used in this HHERA is depicted in Figure 1-2 and discussed in more detail in the following sections.

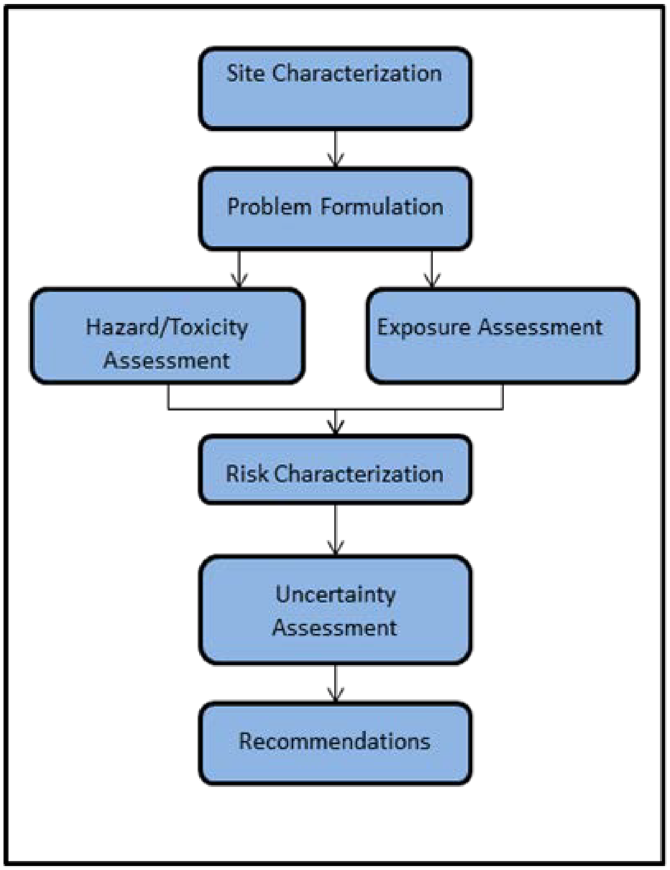

Figure 1-2 Human Health and Ecological Risk Assessment Framework

1.1.1 Site Characterization

The Site Characterization is a process where a review and compilation of existing data is conducted to ensure that the most appropriate data and site information are available to conduct the HHERA. Existing site data may include important site information such as:

- site location;
- historical and current land-use on the site;
- topography;
- geology; and,
- hydrogeology.

1.1.2 Problem Formulation

The Problem Formulation step is an information gathering and interpretation stage that focuses the assessment on the primary areas of concern for the project. The Problem Formulation step defines the nature and scope of the risk assessment, permits practical boundaries to be placed on the overall scope of work, and ensures that the risk assessment is directed at the key areas and issues of concern related to project activities. Based on the data gathered and interpreted within the Site Characterisation step, the Problem Formulation step identifies chemicals of potential concern (COPCs), potential human and ecological receptors, possible exposure pathways, and any other specific issues of concern to be addressed.

The key tasks requiring evaluation within the Problem Formulation step include the identification and characterization of:

- COPCs associated with the site;
- potentially affected environmental media;
- human and ecological receptors; and,
- exposure pathways and routes of exposure.

1.1.3 Exposure Assessment

Human and ecological receptors can come into contact with chemicals in their environment in a variety of ways depending on their daily activities and use of the area. The means by which receptors interact with a chemical in an environmental medium (*e.g.,* air, soil) is referred to as an exposure pathway. The means by which a chemical enters the body from the environmental medium is referred to as an exposure route (*i.e.,* inhalation, direct dermal contact, and ingestion). The Exposure Assessment step incorporates information about chemicals, activities in the area and receptor characteristics to quantify the site-specific exposure pathways.

The magnitude of the exposure of receptors to chemicals in the environment depends on the interaction of a number of variables, including the:

- concentration of COPCs in various environmental media;
- physical-chemical characteristics of the COPCs, which affect their environmental fate and transport and determine such factors as efficiency of absorption into the body;
- influence of site-specific environmental characteristics, such as geology, soil type, topography, hydrology, hydrogeology, local meteorology, and climatology on a COPC's behaviour within environmental media; and,
- physiological and behavioural characteristics of the receptors (*e.g.,* respiration rate, soils/dusts intake, time spent at various activities and in different areas).

1.1.4 Toxicity Assessment

The Toxicity Assessment (also known as the Hazard Assessment) is a process where the toxicity of each of the COPC is determined. Toxicity is the potential for a chemical to produce any type of damage, permanent or temporary, to the structure or functioning of any part of the receptor's body. The toxicity of a chemical depends on the amount of chemical taken into the body (*i.e.,* the "dose") and the duration of exposure (*i.e.,* the length of time the receptor is exposed to the chemical). For each COPC, there is a specific dose and duration of exposure necessary to produce a toxic environmental effect in a given receptor. This is referred to as the "dose-response relationship" of a chemical and is used to calculate the exposure limit (*i.e.,* the concentration or dose of the chemical below which there will be no negative effects). In the case of carcinogenic COPCs, this threshold does not exist in theory since the carcinogenicity model implies that any amount of exposure increases an individual's risk of an adverse health outcome (*i.e.,* cancer). In practice; however, this is not the case, but the toxic potential for human carcinogens is expressed as a concentration or dose associated with an insignificant (1 in a 100,000) incremental increase in risk.

The toxic potency of a chemical (*i.e.,* its ability to produce any type of damage to the structure or function of any part of the body) is dependent on the inherent properties of the chemical itself (*i.e.,* its ability to cause a biochemical or physiological response at the site of action), as well as the ability of the chemical to reach the site of action.

1.1.5 Risk Characterization

The Risk Characterization step integrates the Exposure and Toxicity Assessments to provide a conservative estimate of health risk for the receptors assessed. Potential risks can be characterized qualitatively or quantitatively through a comparison of the estimated or predicted exposures from all pathways (from the Exposure Assessment) with the identified exposure limits (from the Hazard Assessment) for each COPC. For non-carcinogenic COPCs, a hazard quotient is calculated (the ratio of exposure dose to toxicity reference value): for human receptors the threshold of toxicity is 0.2 (0.5 for TEX, F1 and F2) and for ecological receptors it is 1.0. The potential for carcinogenic health effects for human receptors is estimated by multiplying the exposure dose by the toxicity reference value to derive an Increased Lifetime Cancer Risk (ILCR). The threshold of toxicity for a cancer-causing COPC is $1x10^{-5}$, or 1 additional case of cancer in 100,000 people in a population.

1.1.6 Discussion and Recommendations

The Discussion section describes the results of the Risk Characterization and explains the results of the risk assessment. The important outcomes of the risk assessment are described in this section. A list of recommendations that could be considered to further understand the potential risks posed by hazards at the site are explained. Recommendations are presented where risk are present on the site. These recommendations are developed to limit or reduce the risk posed on the site.

2.0 SITE CHARACTERIZATION

In order to assess the potential risk to potential on-site receptors at the Site, it is necessary to have an understanding of current and historical site conditions. This summary is intended to provide sufficient detail to permit review and appreciation of the HHERA; however, additional details are provided in the Phase II Environmental Site Assessment reports (Stantec, 2013a,c).

2.1 Site Location

The facility is the CCG Southside Base and is located on the Southside Road in St. John's, NL. The facility currently consists of an Administration Building, a Buoy Maintenance Facility, Berth 28 and a Hazardous Material Storage Area. The area of the current study (*i.e.,* this HHERA) is the area adjacent to the Buoy Maintenance Facility known as Berth 28 (Pier 28).

Berth 28 (the Site) is currently being used as an equipment storage yard and parking area for the CCG Southside Base. This area is intended to be the future location of the CCG Southside Base office tower. The office tower will be located on the eastern portion of the Site between the property boundary and the City of St. John's sewer outfall. Although the final design is unknown, from discussions with PWGSC, it is anticipated that the building will be a slab-on-grade multi-story office tower with a footprint of approximately 1,850 m^2 (see Drawing Nos. 121412715-EE-02 and 121412715-EE-03 in Appendix A).

The Site is located in an industrial area along the Southside of the St. John's Harbour front. The CCG Buoy Maintenance Facility of the CCG Southside Base (Pier 29) is located adjacent to the southwest of the Site. To the northeast of the Site is HMCS Cabot (Pier 27). Southside Road is located to the southeast of the Site, and the waters of the St. John's Harbour are to the northwest.

The Berth 28 property is approximately 1 ha in area consisting of the concrete deck/wharf and the land up-gradient of the wharf. Southside Road, which borders the property to the southeast, provides site access.

2.2 Historical Land Use

Historical land use for the Site and adjacent properties was determined through a review of historic aerial photography and fire insurance plans as listed below in Table 2.1.

Table 2.1 Summary of Records Reviewed

Source	Information
Fire Insurance Plans	• 1880, 1893, 1914 (revised 1925), 1946, 1964 (City of St. John's Archives)
Aerial Photography	• 1941, 1948, 1951, 1966, 1973, 1976, 1979, 1981, 1982, 1985, 1995, 2003 (Air Photo and Map Library, Newfoundland and Labrador Department of Environment and Conservation)

A summary of the information contained on the fire insurance plans is presented below in Table 2.2.

Table 2.2 Summary of Fire Insurance Plans

Date/Period	Land Use
1880	Site and adjacent properties along the harbour front were used for warehouse storage (Captain E. White); a seal oil factory (skin storage, sunning tanks, seal vats), oil and fish storage, shed (J. & W. Stewart); salt, oil and lumber storage, wooden seal vats (P. & L. Tessier); and, storage of fish, coal and salt, a cooperage (barrel making), wooden seal vats and tanks (Bowring Brothers)
1893	Site and adjacent properties along the harbour front were used for fish storage and cooperage (Jas. Baird Ltd.); fish flakes, sheds, a cooperage, coal sheds, flour/molasses storage (Thos. Walsh); salt and empty fish casks storage, coal and cod oil storage, fish and salt storage, marine supplies and an ice house (Baine Johnston); and, fish warehouse, general warehouse, seal oil factory (seal oil tanks, sunning tanks, pressing house), coal and salt shed (Bowring Brothers)
1914 (revised 1925)	Site and adjacent properties along the harbour front were used for a coal shed (Cashin & Co. Ltd.); warehouse storage, cooperage, fish flakes and stage (Jas. Baird Limited); warehouse storage, repair shop, cod oil storage, oil storage tanks, fish dryers (Baine Johnston); oil warehouse, cooperage, machine shop (gas engine shop), fish warehouse, cask storage and seal oil factory (seal oil tanks, skinning oil loft, sunning pans, pressing house) (Bowring Brothers); and, to the northeast of the Site near Southside Road was a 50 foot (15.2 m), 35,000 gallon (132,500 L) aboveground oil storage tank (AST)
1946	Site and adjacent properties along the harbour front were used for a vocational training school; a fish oil warehouse/seal oil tanks, two (2) dwellings (C. Ellis); a coal shed, five (5) steel fuel oil ASTs at 15,000 gallons (56,800 L) each (Cashin & Co. Ltd. and Cashin Oils Ltd.); general warehouses, cod oil storage, salt warehouse, barrel storage and cooperage, oil warehouse, machine shop and smokehouse (Baine Johnston & Co. Ltd.); fertilizer stage, cask stage, seal oil factory (sunning tanks, skinning loft, pressure cookers, seal oil tanks) and four (4) steel tanks (Bowring Bros.)
1964	Site and adjacent properties along the harbour front were used for a general warehouse (Newfoundland Great Lakes Steamships Ltd.); a fish oil and hide warehouse, seal oil tanks, seal oil steam cookers, general warehouse, four (4) dwellings, warehouse, pumphouse, five (5) steel fuel oil ASTs at 15,000 gallons (56,800 L) each (J. C. Ellis); general warehouse, salt storage, barrel stage and cooperage (Baine Johnston & Co. Ltd.); oil warehouse and pattern shop, fertilizer and general warehouse, machine shop, smokehouse, barrel stage, seal oil factory (sunning pans and tanks, seal oil tanks) and steel fuel tanks (Bowring Bros.)

A summary of the information contained on the aerial photographs are presented below in Table 2.3.

Table 2.3 Summary of Aerial Photography

Year	Comment
1941 & 1948	Clarity of aerial photograph is low, but signs of buildings and development on the site and adjacent properties along the harbour front. Southside Road is present. Similar to 1946 fire insurance plan.
1951	Similar to 1948 aerial photograph.
1966	Similar to 1964 fire insurance plan.
1973 & 1976	Similar to 1964 fire insurance plan.
1979	Buildings present on northeast side of Site. Southwest side of site is vacant. Appears to be six (6) ASTs on northeast side of site near Southside Road.
1982 &1985	Similar to 1979 aerial photograph.
1995	One (1) building on northeast side of site. The ASTs on northeast side of site near Southside Road are no longer present.
2003	No buildings are present on the Site. Site is used as a laydown/storage yard.

2.3 Soil, Topography and Hydrogeology

Based on the results of boreholes drilled as part of previous environmental and geotechnical investigations completed at the Site (Stantec, April (2013a) and May (2013b)), the following sections provide a description of the subsurface conditions encountered at the Site.

A layer of fill material ranging in thickness from 0.6 m to 6.9 m underlies the surficial layer of asphalt or reinforced concrete slab at the Site. Based on the geotechnical report, the fill generally can be sub-divided into an upper and lower layer. The upper layer of fill appeared to consist of a compacted engineered structural fill material described as a dense to very dense, grey to brown to black, silty sand with gravel to well-graded gravel with sand and silt and contained trace amounts of cobbles. The lower fill layer was generally noted to be very loose to dense, grey to black, silty sand with gravel to a poorly graded sand with gravel and silt containing a varying amount of (trace to frequent in content) one or more of the following: wood debris, wood branches, undifferentiated organic matter and glass debris. This lower fill layer was generally consistent in nature with material placed in an uncontrolled, non-engineered manner.

A discontinuous layer of very loose to compact, brown to black, silty sand with gravel with trace to frequent amounts of organic matter consistent with a marine depositional environment was encountered below the layer of fill material. A native glacial till layer ranging in thickness from 0.3 m to 4.1 m was encountered underlying the fill or marine sediment. The till was generally composed of compact to very dense, brown to grey, silty sand with gravel to poorly or well-graded gravel with silt and sand, and contained trace amounts of cobbles.

Bedrock was encountered below the till layer. The depth to bedrock varied from about 0.8 m on south east boundary of the Site to 11.6 m toward the edge of the pier. The bedrock was described as greyish green to bluish grey, siltstone and sandstone sedimentary rocks. The quality of the bedrock was generally very severely fractured at the bedrock surface, becoming moderately jointed or intact with depth.

The Site is relatively flat with a slope along the southwest boundary of the Site. Surface water drainage on the Site is expected to flow towards the St. John's Harbour, located adjacent to the Site along the northwest boundary. Two catch basins are present on the Site. All storm water drainage is either by these catch basins or overland flow.

The depths to groundwater in the monitor wells, as measured between February 24, 2013 and March 12, 2013 during groundwater sampling for the Phase II ESA, ranged from 0.50 m below ground surface (mbgs) in monitor well BH10 to 2.42 mbgs in monitor well BH15 (as provided in Table 2.4). However, groundwater levels are expected to vary seasonally and in response to individual precipitation events, as well as in response to diurnal tidal fluctuations. In particular, groundwater level fluctuations ranging from 0.5 to 1.0 m per day have been recorded in response to tidal fluctuations on other harbor properties in the area. Based on the local topography and the measured groundwater levels, the inferred direction of local groundwater flow at the site is towards the St. John's Harbour to the northwest, as shown on Drawing No.

121412715-EE-02 in Appendix A. The characteristic permeability of the soils at the Site is expected to be moderate.

Table 2.4 Measured Groundwater Depths and Elevations at the Site

Borehole I.D.	Date Measured	Groundwater Depth (mbgs)	Monitor Well Top of Casing Elevation (m)	Groundwater Elevation (masl)*
BH1	12-Mar-13	1.64	2.06	0.42
BH2	12-Mar-13	2.30	2.08	-0.22
BH3	6-Mar-13	1.40	2.07	0.67
BH4	12-Mar-13	2.36	2.15	-0.21
BH5	12-Mar-13	1.96	2.21	0.25
BH6	12-Mar-13	2.16	2.14	-0.02
BH7	12-Mar-13	1.89	2.11	0.22
BH8	12-Mar-13	1.38	2.35	0.97
BH9	12-Mar-13	1.48	2.58	1.10
BH10	5-Mar-13	0.50	2.55	2.05
BH11	12-Mar-13	0.70	2.85	2.15
BH12	3-Mar-13	1.20	2.71	1.51
BH13	12-Mar-13	2.19	2.24	0.05
BH14	24-Feb-13	1.90	2.32	0.42
BH15	12-Mar-13	2.42	2.41	-0.01

Note:
mbgs = meters below ground surface.
masl = meters above sea level.
* = Elevations based on reference to NAD 83 geodetic datum.

2.4 Previous Investigations

The following is a list of previous environmental reports that have been completed at the Site and used as part of this study to develop a conceptual model of the Site (in chronological order):

- Phase II Environmental Site Assessment at Canadian Coast Guard Base, Berth 28, Southside, St. John's Harbour, St. John's, NL, MGI Limited, November 2001;
- Phase II Environmental Site Assessment, Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL, Stantec Consulting Ltd., May 6, 2013; and,
- Groundwater Resampling Program, Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL, Stantec Consulting Ltd., September 17, 2013.

In 2001, a Phase II ESA was completed at the CCG Base, Berth 28. The investigation involved the placement of ten (10) test pits on the Site. Samples collected from the test pits were analyzed for petroleum hydrocarbons (PHCs), metals and PAHs. Exceedances of PHCs, metals and PAHs concentrations greater than the applicable guidelines at the time were noted.

In 2013, a Phase II ESA was carried out and included the drilling of fifteen (15) boreholes that were all completed as monitoring wells. No free liquid phase PHCs were observed on the soil and groundwater collected from any of the monitoring wells. Samples (soil and groundwater) collected from the monitoring wells were analyzed for PHCs, metals, PCBs and PAHs. Concentrations of PHCs, metals and PAHs greater than the applicable guidelines were present in samples collected. Concentrations of PCBs were not detected in any of the soil or groundwater samples analyzed. The extent of impacts in soil and groundwater based on results of the Phase II ESA are shown on Drawing No. 121412715-EE-02 in Appendix A.

During the Phase II ESA groundwater sampling program, the presence of sediment was noted in a number of groundwater samples submitted for analysis that returned elevated concentrations of polycyclic aromatic hydrocarbons (PAHs) and mercury. Since, it is possible that the concentrations of PAHs and mercury identified in the groundwater samples could potentially be influenced by PAHs and mercury contents in the sediment, a groundwater resampling program was completed by Stantec on May 14, 2013 to verify actual groundwater concentrations of PAHs and mercury prior to commencing the Human Health and Ecological Risk Assessment for the property.

Results showed a reduction in the concentrations of PAHs and mercury as compared to those for the Phase II ESA for the monitor wells reassessed suggesting that PAHs and mercury concentrations in the groundwater samples collected during Phase II ESA were likely influenced by sediment content, and may not have been representative of actual groundwater conditions. Results of the resampling program completed on May 14, 2013 indicate that with the exception of mercury in groundwater in monitor well BH15, PAHs and mercury in the other groundwater samples analyzed ranged from non-detect to very low concentrations that were below applicable guidelines. These results are considered to represent actual groundwater conditions at these monitor well locations. Further, since the four (4) monitor wells selected for resampling during the current program contained the highest concentrations of PAHs and mercury in groundwater during the Phase II ESA program, it is assumed that these concentrations are also conservatively representative of PAHs and mercury concentrations in groundwater at the other monitor wells location on the Site. As such, concentrations of PAHs and mercury in groundwater identified as part of the resampling program were carried forward as representative of actual groundwater conditions for the Site in the HHERA.

3.0 SOIL VAPOUR SAMPLING

Due to identified exceedances of petroleum hydrocarbons in soil in the vicinity of the proposed site building, soil vapour data was collected as part of the current HHERA to evaluate the potential for vapour intrusion and predict the indoor air concentrations once the building is completed. The highest concentration of petroleum hydrocarbons in soil identified in this area occurred in borehole BH03 from a depth of 2.6 – 3.6 mbgs, with a reported total petroleum hydrocarbon concentration of 40,000 mg/kg.

3.1 Methodology

3.1.1 Vapour Probe Drilling and Installation

A total of four (4) soil vapour probes, labeled VP01 to VP04, were installed at the site for the purposes of carrying out soil vapour sampling. This work was carried out in support of the HHRA to evaluate the potential for vapour intrusion into the proposed site building as a result of subsurface petroleum hydrocarbon impacts present on the property. The locations of the soil vapour probes are shown on Drawing No. 121412715-EE-02 in Appendix A. The soil vapour probe locations were selected by Stantec in consultation with the client within the area of petroleum hydrocarbon-impacted soil in the vicinity of the proposed building, as identified as part of the Phase II ESA. The locations of the vapour probes in the field were placed by Stantec personnel referencing known site infrastructure.

The boreholes were drilled on July 10, 2013 using a track-mounted CME-55 geotechnical drill rig and solid stem auger (250 mm diameter) drilling techniques, and were advanced through the loose fill and native overburden layers to a termination depth of 1.5 m below ground surface (mbgs). Drilling equipment, supplies, and personnel were provided by Logan Drilling Group of Stewiacke, Nova Scotia. Fieldwork was managed on a full-time basis by Stantec personnel who kept detailed records of subsurface and drilling conditions. Following drilling, a soil vapour probe was installed within each borehole and consisted of 1.0 m of 25 mm diameter, flush-threaded, Schedule 40 solid PVC riser followed by 0.5 m of No. 10 slot screen over the lower section of each borehole from 1.0 – 1.5 mbgs. Silica sand was placed around the screened section of the probe, and extended to approximately 0.65 mbgs. A bentonite seal was placed above the sand pack, and was extended to the surface. The details of subsurface conditions encountered during drilling as well as specific soil vapour probe construction details are presented on the Monitor Well Records provided in Appendix C. Following installation and prior to sampling, each soil vapour probe was left undisturbed for a period of 48 hours to allow for equilibration of soil gas within the probe.

The installation depths of the soil vapour probes were dictated by the shallow groundwater table on site, which in the area of concern was found to be approximately 2 mbgs at the time of the Phase II ESA field investigation. While the depths of the soil vapour probes are considered to be shallow, various guidance documents (including ITRC (2007)) suggest that various surface effects such as atmospheric pumping, precipitation, and advective flow induced from an overlying structure are considered to be minimized at a sample depth of 1.0 – 1.5 mbgs. Further the screened section of the vapour probes from 1-1.5 mbgs is within ½ the depth to the most significant petroleum hydrocarbon impacts in soil identified in borehole BH03 from 2.6 – 3.6 mbgs, as recommended by Health Canada guidance (Health Canada, 2010d). Therefore the soil vapur probes installed as part of this investigation are considered to be suitable for collection of soil vapour data to provide a screening-level estimate of future sub-slab conditions beneath the proposed building.

3.1.2 Soil Vapour Sampling and Analysis Procedures

On July 12, 2013 soil vapour sampling was carried out in the four (4) soil vapour probes installed at the site. At each sample location, a soil vapour sample was collected using a certified clean, evacuated 1.4-L Summa canister equipped with a dedicated, laboratory-set flow regulator to collect a time-integrated 1-hr air sample (*i.e.,* approximately 0.02 liters per minute flow rate).

Prior to purging and sampling activities, leak testing was attempted using a tracer gas (helium) shroud to verify the integrity of the seal of the soil vapour probe and sampling train. However, due to the irregular, asphalt ground surface at the soil vapour probe locations, the shroud could not be properly sealed and saturated with the tracer gas, preventing proper execution of the test. While proper leak testing could not be performed at the soil vapour locations, the approximately 0.65 m (2') thick bentonite seal at the surface of the soil gas probes, and the use of air-tight valves and fittings in the above-ground sampling train combined with the low sampling flow rate of 0.02 L/min are thought to have minimized any potential for infiltration of ambient air into the soil vapour samples during sample collection.

To ensure collection of representative soil vapour samples, three (3) purge volumes (calculated based on the volume of the soil vapour probe) were purged at a flow rate of 0.02 liters per minute from each soil vapour probe prior to sampling. Table 3.1 provides a summary of information collected during soil vapour sampling at the site. The soil vapour samples were collected over a period of 70 to 90 minutes to fill the Summa canisters to <10 inches of mercury (Hg). Each canister had an initial field vacuum reading of at least 28 inches of Hg prior to sampling and had a final field vacuum reading of 1.5 to 4.5 inches of Hg upon the completion of sample collection according to the vacuum gauges attached to the canisters. The Summa canisters were shipped to Maxxam Analytics Inc. in Mississauga, ON for analysis of BTEX, TPH fractionation (aliphatics and aromatics) using USEPA Method TO-15mod. Full chain of custody documentation was maintained for all canisters from time of shipping from the laboratory to the time of analysis.

Table 3.1 A Summary of Soil Vapour Sampling Information

Location	Sample period (mins)	Date Collected	Volume (L)	Starting Pressure (inches Hg)	Finishing Field Pressure (inches Hg)
VP01	70	12 July 2013	1.4	-28	-1.5
VP02	90	12 July 2013	1.4	-29.5	-4.5
VP03	88	12 July 2013	1.4	-29.5	-1.5
VP04	72	12 July 2013	1.4	-29.5	-3.5

3.1.3 Quality Assurance/Quality Control Program

A summary of the quality assurance/quality control (QA/QC) program for the current program is presented below:

- The field sampling personnel documented all field activities including sample identification, location and date and time of sample collection, sampling methods and devices, weather conditions (temperature, barometric pressure, wind direction, wind speed, humidity, and precipitation), chain-of-custody records to track samples from sampling point to analysis.
- Only certified clean sampling devices were used for air sampling, and precautions were taken to avoid sample interference.
- Once the samples were collected, they were stored according to the method protocol (USEPA TO-15mod) and delivered to the analytical laboratory as soon as possible so that sample-holding times were not exceeded.
- Chain of Custody forms were filled out for all lab shipments with Stantec personnel keeping a legible copy.

In addition, the Maxxam Analytics laboratories have an extensive QC program in place to ensure that reliable results are consistently obtained. Specific laboratory QC measures include:

- Chain of Custody and sample integrity inspection;
- Strict documentation control and files;
- Trained personnel prepare and analyze samples according to Standard Operating Procedures;
- All analytical methods are based on accepted (*e.g.,* CALA) procedures and are fully validated prior to use;
- Precision is monitored by performing replicate analysis of samples within each batch (dependent on batch size);
- Accuracy is verified by analyzing spiked samples and reference materials within each batch (dependent on batch size);
- Instrument calibration integrity is ensured by analyzing calibration check standards within each run sequence;
- Matrix effects in organic analyses are assessed with surrogate fortification of each sample;
- Extensive use is made of reference material for routine procedure evaluation;
- Highest available purity analytical standards;
- Predefined analytical sequences ensure all results are traceable to calibration and QC data;
- Hard copy reports displaying all of the required data are generated for each instrument;
- Analytical results are determined only from instrument responses that fall within the calibration range;

- Acceptable QC performance must be demonstrated prior to data authorization (data are subject to three levels of QC review: chemist, supervisor and manager);
- On-going method and instrument performance records are maintained for all analyses; and,
- Records containing all pertinent data are securely archived for three years.

3.2 Soil Vapour Results

A summary of the results of the laboratory analysis for petroleum hydrocarbon compounds (*i.e.,* BTEX and TPH fractionation (aliphatics and aromatics)) of the four (4) soil vapour samples collected at the site are provided in Table 3.2. Full laboratory analytical results are also presented in Table C.1 in Appendix C, along with the Maxxam Analytics laboratory certificates.

Table 3.2 Summary of Laboratory Analytical Results – Soil Vapour Samples

Parameter	VP1 (µg/m^3)	VP2 (µg/m^3)	VP3 (µg/m^3)	VP4 (µg/m^3)
Benzene	3.70	16	118	1,590
Toluene	5.5	14.7	71	936
Ethylbenzene	<1.6	13.3	59	2,420
Xylenes	5.2	67	207	8,010
Aliphatic >C_5-C_6	12.7	14.4	577	29,900
Aliphatic >C_6-C_8	50.2	60.2	4,710	82,300
Aliphatic >C_8-C_{10}	39	104	13,800	62,200
Aromatic >C_7-C_8	<5	<5	<5	<5
Aromatic >C_8-C_{10}	6.6	135	573	16,400
Aliphatic >C_{10}-C_{12}	118	191	25,100	33,900
Aliphatic >C_{12}-C_{16}	156	200	5,650	3,500
Aromatic >C_{10}-C_{12}	8.4	287	2,070	17,600
Aromatic >C_{12}-C_{16}	<5	42.7	1,650	569
Total Petroleum Hydrocarbons	417	1,150	54,590	259,330

Soil vapour analytical results indicate the presence of petroleum hydrocarbons in all four (4) of the soil vapour samples collected at the site, with total petroleum hydrocarbon concentrations ranging from 417 µg/m^3 in soil vapour probe VP1 to 259,330 µg/m^3 in soil vapour probe VP4. This soil vapour data is presented further in Section 4 of this report where it is used to predict future concentrations of petroleum hydrocarbons in indoor air in the proposed site building and to evaluate whether petroleum hydrocarbon impacted soil on the property poses a health risk to future occupants of the proposed site building.

Overall, a wide range of petroleum hydrocarbon vapour concentrations were measured in the soil vapour probes installed at the site showing several orders of magnitude variation. Further, there appears to be a general lack of correlation between petroleum hydrocarbon vapour concentrations measured during this study, and soil concentrations identified in adjacent boreholes as part of the Phase II ESA. In particular, the vapour probe (VP1), installed within the area of highest concentrations of petroleum hydrocarbons in soil identified in borehole BH03 (*i.e.,* 40,000 mg/kg), returned the lowest petroleum hydrocarbon vapour concentrations measured at the site; while the highest petroleum hydrocarbon vapour concentrations were measured in soil vapour probe VP4, located approximately 10 m south of borehole BH03 near existing borehole BH06 where much lower concentrations of petroleum hydrocarbons were identified in soil (*i.e.*, 7,700 mg/kg) during the Phase II ESA. This inconsistency in the spatial distribution of petroleum hydrocarbons vapour concentrations at the site with the spatial distribution of soil concentration data is not known for certain. However, a number of site-specific factors might be expected to be of influence, including soil heterogeneity, presence of underground conduits/infrastructure and hydrogeology. In particular, the petroleum hydrocarbon impacted soil present in borehole BH03 was identified below the groundwater table at the time of the Phase II ESA investigation (*i.e*., groundwater table at 2.3 mbgs versus zone of impacts from 2.6 – 3.6 mbgs). While, tidal fluctuations may result in periodic exposure of these impacts to the vadose zone and the potential for vapour-phase generation, under saturated conditions, air-filled porosity would be expected to be reduced resulting in a barrier to vapour-phase generation and dispersion.

4.0 HUMAN HEALTH RISK ASSESSMENT

The purpose of this Human Health Risk Assessment (HHRA) is to evaluate the potential that human receptors may experience toxicologically induced changes in health as a result of exposure to COPCs found at the Site. The potential for adverse health effects is quantified by comparing the amount of a substance that can be tolerated, (*i.e.,* below which adverse environmental effects are not expected (*e.g.,* toxicity reference value (TRV) or toxicity benchmarks)), to the amount of a COPC to which a receptor is expected to be exposed to, or come into contact with, on a daily basis. The quotient of the two and the magnitude by which values differ from parity (*e.g.,* TRV = daily dose) is used to make inferences about the possibility of human health risks.

As previously stated (Section 1.0), the HHRA process follows a widely recognized framework that progresses from Site Characterization to a qualitative initial phase (Problem Formulation), through Exposure and Toxicity (Hazard) Assessments, and culminates in a quantitative Risk Characterization. Following this, a discussion of the uncertainties inherent to the HHRA and Conclusions and Recommendations stemming from the assessment are discussed.

The primary guidance for conducting the HHRA was Health Canada's guidance, including:

- Health Canada. 2010a. Federal Contaminated Site Risk Assessment in Canada Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA).
- Health Canada. 2010b. Federal Contaminated Site Risk Assessment in Canada Part II: Health Canada Toxicological Reference Values (TRVs).

- Health Canada, 2010c. Federal Contaminated Site Risk Assessment in Canada Part V: Guidance on Complex Human Health Detailed Quantitative Risk Assessment for Chemicals ($DQRA_{Chem}$).

4.1 Problem Formulation

The key tasks requiring evaluation within the Problem Formulation step include the identification and characterization of:

- COPCs associated with the site;
- Potentially affected environmental media;
- Human receptors; and,
- Exposure pathways and routes of exposure.

The HHRA incorporates environmental site investigation data from 2013 (Stantec Report No. 121412551*, Phase II Environmental Site Assessment, Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL*), as well as the results of the subsequent groundwater resampling program on May 14, 2013 into a realistic human health exposure scenario to identify the risks posed by chemical concentrations at the Site to human receptors (data located in Appendix B). If necessary, the requirements for remediation or risk management measures will be developed, given the current and potential future land uses. The current land use at the Site is industrial land use. However, this HHRA also considers future land use at the site, which is considered to be a commercial property (no day care) with a slab-on-grade multi-story office tower having a footprint of approximately 1,850 m^2.

4.1.1 Hazard Identification

For federal lands, the CCME defines guidelines to assess chemical impacts. COPCs are those compounds present at a Site with the potential to impose adverse health effects under certain conditions (*i.e.,* if present at sufficient quantities and available to human receptors, particularly during sensitive life stages). For this HHRA, it was decided that the maximum concentration of each chemical would be conducted to screen the COPCs for this Site. For direct contact pathways, a secondary screening was completed by comparing the exposure point concentration (calculated as an upper confidence limit on the mean) to the CCME guidelines for dermal contact.

The use of an upper confidence limit on the mean (UCLM) is more representative of the COPC concentrations that are present across the Site as a whole and provides a more realistic estimate of the reasonable exposure for a receptor moving across the Site over numerous visits for direct contact pathways. The UCLM is a statistical representation of the upper bound of the average concentration of COPC within the impacted portion of the Site. To determine the appropriate UCLM, the program ProUCL ® (Version 4.1.0 by U.S. EPA) was used and the UCLM recommended by ProUCL ® was selected. However, the UCLM can only be calculated for those chemicals for which the number of detected values in the dataset was sufficiently large (*i.e.,* greater than 8-10 detected values), as per US EPA (US EPA, 2010). In this case, the 95th percentile of the data distribution was used as the EPC (as per Health Canada, 2010c) to be screened against the applicable guideline.

4.1.1.1 Soil

Soil samples collected by Stantec in 2013 make up the dataset considered in this HHRA (n=20). The MGI petroleum hydrocarbon data collected in 2001 was not quantitatively used in this HHRA due to the possibility that this data, which are over 12 years old, may not be representative of current site conditions. It is common practice in HHRAs, and regulated in some jurisdictions (*e.g.,* Ontario), that where sufficient newer data is available that the newer data would supersede the older data. In addition, the soil samples collected by Stantec in 2013 are from across the Site and are located in areas where MGI data was collected in 2001. Therefore, the soil samples collected by Stantec in 2013 are considered to be representative of the current site conditions. Soil samples were obtained on the Site from a depth between 0 m to 6.3 m below ground surface (mbgs).

All parameters were screened against the applicable CCME human health-based soil quality guidelines (SQG_{HH}). For several of the SQG_{HH}, the CCME also provides pathway-specific guidelines, therefore, human health-based guidelines were selected for the screening based on the pathways applicable to the commercial land use scenario. The lesser of direct contact or the vapour inhalation (indoor air slab-on-grade) guidelines, for commercial land use was used in the COPC screening.

In the absence of federal guidelines, Alberta Tier 1 Surface Soil Remediation Guideline Values for human direct soil contact, vapour inhalation and off-site migration (Table A-4: All exposure pathways) were selected, followed by applicable Ontario Ministry of the Environment (OMOE) component criteria. Alberta Tier I (AENV, 2010) guidelines were derived using the CCME (2006) soil protocol and as such are considered consistent with federal guidelines. Ontario MOE (2011) criteria components for non-carcinogenic parameters were selected from the Full-Depth, Non-Potable Water Scenario criteria for commercial land use, coarse textured soils, based on the lesser of the commercial soil contact (S2), and indoor air (S-IA) values.

Petroleum Hydrocarbons (PHCs)

The screening values and maximum soil concentrations of BTEX and PHC fractions are presented in Table 4.1. Benzene, and F1 and F2 petroleum hydrocarbon fractions were PHCs determined to be COPCs in soil. Therefore, the EPCs for these COPCs were then screened against the applicable guideline to determine if these COPCs needed to be assessed further in the HHRA. The EPCs for benzene, and F1 and F2 petroleum hydrocarbon fractions were greater than the applicable guideline. Therefore, benzene, and F1 and F2 petroleum hydrocarbon fractions were carried forward for further assessment in the HHRA for exceeding the indoor air pathway, but not for direct contact.

Table 4.1 Human Health Screening - Soil (PHC)

COPC	Maximum Concentration (mg/kg)	Soil to Indoor Air (mg/kg)	Maximum > Indoor Air Guideline	Direct Contact (mg/kg)	Maximum > Direct Contact Guideline	EPC	EPC > Direct Contact Guideline
Benzene	**0.83**	**0.3 A**	✓	110 A	×	--	--
Toluene	0.29	1400 A	×	82,000 A	×	--	--
Ethylbenzene	1.8	630 A	×	36,000 A	×	--	--
Xylenes, Total	4	160 A	×	560,000 A	×	--	--
PHC F1 (C6-C10) - BTEX	**1,400**	**320 B**	✓	19,000 B	×	--	--
PHC F2 (C10-C16 Hydrocarbons)	**24,000**	**1,700 B**	✓	10,000 B	✓	5,100	×
PHC F3 (C16-C34 Hydrocarbons)	14,300	NA B	×	23,000 B	×	--	--

Note:
A – CCME Canadian Soil Quality Guidelines for the protection of Environmental and Human Health. Commercial Land Use; Coarse Textured Soil. Lowest of the applicable human health pathways (Ingestion, Direct Contact, Vapour Inhalation, and Offsite Migration).
B – CCME Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil, 2008 – Commercial land use, coarse textured soil.
NV - No value provided in this source for this parameter
NA – Not Applicable
-- EPC not calculated
Shaded/Bolded – carried forward for further assessment.

Polycyclic Aromatic Hydrocarbons (PAHs)

The screening values and maximum soil concentrations of PAHs are presented in Table 4.2. The CCME only has human health guidelines for carcinogenic PAHs, expressed as Benzo(a)pyrene Total Potency Equivalents (B(a)P TPE). The concentration of each carcinogenic PAH is multiplied by the applicable B(a)P Potency Equivalence Factor (PEF), and a B(a)P TPE is calculated by summing the results. The CCME B(a)P PEFs are provided in Table 4.2, as well as the maximum soil PAH concentration and the resulting B(a)P TPE.

Since the calculated B(a)P TPE (24.1 mg/kg), based on maximum concentrations of carcinogenic PAHs in soil at the site was greater than the CCME human health-based SQG for carcinogenic PAHs (*i.e.,* 5.3 mg/kg), carcinogenic PAHs as a group were carried forward for further assessment in the HHRA.

The CCME does not provide human health-based SQGs for non-carcinogenic PAHs, but specifies that human health-based guidelines should be found from other jurisdictions for the screening of non-carcinogenic PAHs. Non-carcinogenic PAHs were therefore screened against applicable guidelines from Alberta Tier 1 values (2010) or the Ontario MOE (2011).

Table 4.2 Human Health Screening - Soil (PAHs)

COPC	Maximum Concentration (mg/kg)	CCME SQG[A] B(a)P PEF	Maximum Carcinogenic PAH Concentration X B(a)P TEF (mg/kg)	Soil to Indoor Air (mg/kg)	Maximum > Indoor Air Guideline	Direct Contact (mg/kg)	Maximum > Direct Contact Guideline	EPC	EPC > Direct Contact Guideline
Non-Carcinogenic PAHs									
Acenaphthene	12	NV	NV	43,000[B]	×	8,000[B]	×	--	NA
Acenaphthylene	5			6.6[C]	×	9.6[C]	×	--	NA
Anthracene	20			NGR[B]	×	37,000[B]	×	--	NA
Fluoranthene	64			NGR[B]	×	5,300[B]	×	--	NA
Fluorene	21			91,000[B]	×	4,100[B]	×	--	NA
1- Methylnaphthalene	12			160[C]	×	560[C]	×	--	NA
2- Methylnaphthalene	13			160[C]	×	560[C]	×	--	NA
Naphthalene	**38**			**25[B]**	✓	2,800[B]	×	--	NA
Pyrene	52			NGR[B]	×	3200[B]	×	--	NA
Perylene	3.6			9.6[E]	×	6.6[E]	×	--	NA
Carcinogenic PAHs									
Benzo(a)anthracene	22	0.1	2.2						
Benzo(a)pyrene	17	1	17						
Benzo(b)fluoranthene	9.8	0.1	0.98						
Benzo(g,h,i)perylene	7.3	0.01	0.073						
Benzo(j)fluoranthene	6.9	0.1	0.69						
Benzo(k)fluoranthene	6.2	0.1	0.62						
Chrysene	21	0.01	0.21						
Dibenzo(a,h)anthracene	1.7	1	1.7						
Indeno(1,2,3-cd)pyrene	5.9	0.1	0.59						
Phenanthrene	19	0.001	0.019						
Benzo(a)pyrene TPE	**NA**	**5.3**	**24.1[D]**	**NA**				**12**	✓

Note:
A – CCME Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health. Commercial Land-Use; coarse textured soil.
B – Alberta Tier 1 Soil and Groundwater Remediation Guidelines. December 2010. Table A-4, Surface Soil Remediation Guideline Values for Commercial Land Use.
C - Ontario Ministry of the Environment Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Sites in Ontario. 2011. Table 3, Full Depth Non-Potable Water Scenario for coarse grained soils. Soil Component Table, Commercial Land Use.
D - The concentration of each carcinogenic PAH is multiplied by the applicable B(a)P PEF, and B(a)P TPE is calculated by summing the results.
E - There are no Canadian guidelines for perylene; therefore, the most stringent of the non-carcinogenic PAH guidelines (Acenaphthylene) have been selected for comparison purposes.
NV - No value provided in this source for this parameter.
NGR – No Guideline Required
-- EPC not calculated; NA – Not Applicable
Shaded/Bolded – carried forward for further assessment.

For the non-carcinogenic PAHs, which were screened against Alberta and MOE criteria, only naphthalene was identified as a COPC. As the pathway of concern is for indoor air, a site-wide EPC was not calculated for naphthalene; but rather the maximum concentration measured in soil on site was used to conservatively represent conditions associated with the future site building. Therefore, no non-carcinogenic PAHs were carried forward for further assessment in the HHRA except for naphthalene.

Polychlorinated Biphenyls (PCBs)

The screening values and maximum soil concentrations of polychlorinated biphenyls (PCBs) are in Table 4.3. As there are no human health-based CCME guidelines, the maximum soil concentrations of PCBs were screened against the commercial human health value in the Alberta guidance. PCBs were not detected at the site and the detection limit is less than the Alberta guideline; therefore, PCBs were not carried forward for further assessment in the HHRA.

Table 4.3 Human Health Screening - Soil (PCBs)

COPC	Maximum Concentration (mg/kg)	Alberta $_{HH}$ [1] (mg/kg)	Carried Forward?
Polychlorinated Biphenyls (PCBs)	<0.05	33	×

Note:
1 – Alberta Tier 1 Soil and Groundwater Remediation Guidelines. December 2010. Table A-4, Surface Soil Remediation Guideline Values for Commercial Land Use. Lowest of the Human Health Values

Inorganic Parameters

Maximum site soil concentrations and screening criteria for inorganic parameters are presented in Table 4.4. Inorganic parameters (mainly metals) are considered non-volatile and are not assessed for vapour intrusion into indoor or outdoor air.

Soil screening levels were identified for all inorganic parameters with the exception of iron. Iron is inherently non-toxic to humans and is listed by the Texas Commission on Environmental Quality (TCEQ) as a compound for which a human health Protective Concentration Level (PCL) is not required (TCEQ, 2007). For all inorganic parameters for which human health-based screening criteria were found, the maximum concentrations measured in site soil were less than the applicable screening levels, with the exception of aluminum, arsenic, and lead. The maximum concentrations of aluminum, arsenic, and lead were greater than the applicable guidelines. The EPCs for these COPCs (aluminum, arsenic, and lead) were then screened against the direct contact guideline to determine if these COPCs needed to be assessed further in the HHRA. The aluminum and arsenic EPCs for the Site were less than the applicable guidelines; therefore, aluminum and arsenic were not carried forward for further assessment. However, the EPC for lead was greater than the applicable guideline and this COPC was carried forward in the HHRA for further assessment.

Table 4.4 Human Health Screening - Soil (Inorganics)

COPC	Maximum Concentration (mg/kg)	Direct Contact (mg/kg)	Maximum > Direct Contact Guideline	EPC	EPC > Direct Contact Guideline
Aluminum	17000	198000 [A]	✓	12900	×
Antimony	4.5	63 [B]	×	--	×
Arsenic	46	31 [C]	✓	13.05	×
Barium	140	10000 [C]	×	--	×
Beryllium	<2	60 [B]	×	--	×
Boron	61	24000 [B]	×	--	×
Cadmium	1	49 [C]	×	--	×
Chromium	51	630 [C]	×	--	×
Cobalt	15	250 [B]	×	--	×
Copper	280	4000 [C]	×	--	×
Iron	17000	INT	×	--	×
Lead	**2700**	**260 [C]**	✓	**480**	✓
Manganese	1100	4600 [A]	×	--	×
Mercury	0.72	24 [C]	×	--	×
Molybdenum	18	1200 [B]	×	--	×
Nickel	73	510 [B]	×	--	×
Selenium	2	125 [C]	×	--	×
Silver	5.3	490 [B]	×	--	×
Strontium	780	122000 [A]	×	--	×
Thallium	0.37	1 [C]	×	--	×
Tin	320	122000 [A]	×	--	×
Uranium	10	33 [C]	×	--	×
Vanadium	45	160 [B]	×	--	×
Zinc	880	47000 [B]	×	--	×

Note:
A - Screening criteria taken from U.S. EPA Risk-Based Concentrations (RBC) for industrial land use (U.S. EPA, 2012), divided by 5 to reflect differences between the U.S. EPA and Health Canada/CCME approach to risk assessment.
B – Ontario Ministry of the Environment Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Sites in Ontario. 2011. Table 3, Full Depth Non-Potable Water Scenario for coarse grained soils. Soil Component Table, Commercial Land Use. Lowest of the Human Health Values
C – CCME Canadian Soil Quality Guidelines for the protection of Environmental and Human Health. Commercial Land Use; Coarse Textured Soil.
-- EPC not calculated
INT – Inherently Non-Toxic
Shaded/Bolded – carried forward for further assessment.

4.1.1.2 Groundwater

Groundwater samples (n=10) were collected by Stantec in September 2013 (depth of groundwater 0.5 m to 2.42 m, Stantec (2013a)). In addition, some groundwater resampling was conducted in May 2013 ((n=2) for PAHs and (n=2) for mercury); details for the resampling are described in detail in Stantec (2013c). Maximum groundwater parameters were screened first against the applicable federal guidelines. The federal guidelines based on indoor inhalation were obtained from the Guidance Document on Federal Interim Groundwater Quality Guidelines for Federal Contaminated Sites (2012b) Table 3 Generic Guidelines for Commercial and Industrial Land Uses, inhalation criteria. Where no federal values were present, Alberta (AENV, 2010) guidelines were used.

In the absence of federal and Alberta guidelines, the MOE (2011) groundwater components for a non-potable water scenario (GW2) for coarse textured soil were used. If no non-potable guidelines were available and the chemical was considered relatively non-volatile, drinking water guidelines were used to conservatively assess the incidental and dermal contact some receptors (*e.g.,* construction worker) may have with the groundwater.

COPCs with non-detectable concentrations and no available guideline or standard were not carried forward into the risk assessment. It was assumed that these compounds were not present on site at concentrations that would pose adverse health effects to human receptors.

The screening of groundwater COPC is shown in Table 4.5 to Table 4.7.

Petroleum Hydrocarbons

The screening values and maximum groundwater concentrations (March 2013; no resampling for PHCs conducted in May 2013) of BTEX and PHC fractions are presented in Table 4.5. The maximum BTEX and PHC fraction groundwater concentrations were all less than analytical detection limits which, in turn, were less than the applicable guidelines. Consequently, no BTEX or PHC fractions were carried forward into the HHRA.

Table 4.5 Human Health Screening - Groundwater (PHC)

COPC	Maximum Concentration (mg/L)	$FIGQG_{HH}$[1] (mg/L)	Maximum > Guideline	EPC	Carried Forward?
Benzene	0.016	1.8	×	--	×
Toluene	0.0038	NGR	×	--	×
Ethylbenzene	0.067	NGR	×	--	×
Xylenes, Total	0.12	48	×	--	×
PHC F1 (C6-C10) - BTEX	1.21	9.1	×	--	×
PHC F2 (C10-C16 Hydrocarbons)	1.63	17	×	--	×
PHC F3 (C16-C34 Hydrocarbons)	0.63	NA	×	--	×

Note:
1 – Guidance Document on Federal Interim Groundwater Quality Guidelines for Federal Contaminated Sites. 2012. Table 3 Generic Guidelines for Commercial and Industrial Land Uses (mg/L). Tier 2 Inhalation. Soil Type coarse.
-- EPC not calculated as maximum Site concentration is less than the applicable guideline
NA – Not Applicable
NGR – No guideline required; calculated guideline exceeds solubility limit

Polycyclic Aromatic Hydrocarbon (PAHs)

All of the PAHs tested in March 2013 and May 2013 had a maximum groundwater concentration less than the applicable guideline (Table 4.6). Consequently, no PAHs were carried forward for groundwater in the risk assessment for human health.

Table 4.6 Human Health Screening - Groundwater (PAHs)

COPC	Maximum Concentration (µg/L)	FIGQG$_{HH}$ [1] (µg/L)	MOE GW2 [2] (µg/L)	Maximum > Guideline	EPC	Carried Forward ?
1-Methylnaphthalene	13	38000	--	×	--	×
2-Methylnaphthalene	4.4	38000	--	×	--	×
Acenaphthene	4.5	NGR	--	×	--	×
Acenaphthylene	0.74	NV	750	×	--	×
Anthracene	9.1	NGR	--	×	--	×
Benzo(a)anthracene	12	NV	1800	×	--	×
Benzo(a)pyrene	7.9	NV	2500	×	--	×
Benzo(b)fluoranthene	5.4	NV	250000	×	--	×
Benzo(g,h,i)perylene	3.8	NV	750*	×	--	×
Benzo(j)fluoranthene	3.4	NV	28000	×	--	×
Benzo(k)fluoranthene	3.2	NV	28000	×	--	×
Chrysene	11	NV	63000	×	--	×
Dibenzo(a,h)anthracene	0.89	NV	20000	×	--	×
Fluoranthene	30	NGR	--	×	--	×
Fluorene	6.6	NGR	--	×	--	×
Indeno(1,2,3-c,d) pyrene	2.9	NV	42000	×	--	×
Naphthalene	13	7000	--	×	--	×
Perylene	1.7	NV	750*	×	--	×
Phenanthrene	35	NV	750*	×	--	×
Pyrene	25	NGR	--	×	--	×

Note:
1 – Guidance Document on Federal Interim Groundwater Quality Guidelines for Federal Contaminated Sites. 2012. Table 3 Generic Guidelines for Commercial and Industrial Land Uses (mg/L). Tier 2 Inhalation. Soil Type coarse.
2 – Ontario Ministry of the Environment Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Sites in Ontario. 2011. Table 3, Full Depth Non-Potable Water Scenario for coarse grained soils. Commercial and Industrial Land Use. GW2 Human Health Values. Commercial and Industrial values.
-- EPC not calculated as maximum Site concentration is less than the applicable guideline
* - No guideline was available for this PAH therefore the lowest PAH guideline was used
NV – No Value
NGR – No Guideline Required

Polychlorinated Biphenyls

Data for PCBs are presented in Table 4.7. There are no federal guidelines for PCBs in groundwater. PCBs were not detected in groundwater. The detection limit for PCBs was less than the applicable MOE water guideline (March 2013 data only; no resampling conducted in May 2013). PCBs in groundwater were not carried forward for further assessment in the HHRA.

Table 4.7 Human Health Screening - Groundwater (PCBs)

COPC	Maximum Concentration (mg/L)	MOE GW2 [1] (mg/L)	Carried Forward?
Polychlorinated Biphenyls (PCBs)	<0.05	180	×

Note:
1 – Ontario Ministry of the Environment Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Sites in Ontario. 2011. Table 3, Full Depth Non-Potable Water Scenario for coarse grained soils. Commercial and Industrial Land Use. GW2 Human Health Values.

Inorganic Parameters

The maximum Site groundwater concentrations (*i.e.,* the March 2013 dataset, as well as data for mercury from the subsequent May 2013 resampling event) and screening criteria for inorganic parameters are presented in Table 4.8. Inorganic parameters (mainly metals) are considered non-volatile and are not assessed for vapour intrusion into indoor or outdoor air. With respect to the direct contact pathway, since there are no applicable guidelines for inorganic parameters for this pathway, the groundwater concentrations were compared to drinking water guidelines to conservatively assess the incidental and dermal contact exposure human receptors may have with the groundwater at the site.

For all inorganic parameters for which human health-based screening criteria were found, the maximum concentrations measured in site groundwater were less than the applicable screening levels, with the exception of cobalt, iron, manganese, mercury and sodium. It should be noted that the groundwater samples collected in March 2013 were indicated as having a presence of sediment during laboratory analysis. To determine if the elevated concentrations observed in the groundwater are a result of sediment, the two monitoring wells with the highest concentrations of mercury were resampled in May 2013. The resampling of the two wells with the highest concentrations of mercury resulted in mercury concentrations in groundwater that were less than the previous sampling (March 2013) by an approximate factor of 100 and the concentrations were less than the applicable guideline. Therefore, the elevated concentration of mercury in groundwater was determined to be a result of sediment in the collected samples. As a result, mercury was not carried forward for further evaluation in this HHRA.

There is a possibility that the elevated concentrations of cobalt, iron, manganese and sodium in groundwater is also a result of sediment in the groundwater sample collected in March 2013. In addition to the sediment in the groundwater sample, the elevated concentrations of cobalt, iron, manganese and sodium in groundwater may be a result of seawater influence (especially the sodium) at the Site. It is likely that the influence of seawater on the site and the possibility of sediment interferences are the primary causes of the elevated concentrations of cobalt, iron, manganese and sodium in groundwater at the site. Further, the exceedances for cobalt, iron, manganese and sodium are based on the groundwater being utilized as a drinking water source and are based on aesthetic objectives. As the groundwater at this site is not utilized as a drinking water source, these parameters were not carried forward for further assessment.

Table 4.8 Human Health Screening - Groundwater (Inorganics)

COPC	Maximum Concentration (µg/L)	MOE GW1[1] (µg/L)	CDWQG Guideline[2] (µg/L)	Other	Maximum < Guideline	EPC	Carried Forward?
Aluminum	51.9	NV	NV	3,200[A]	×	--	×
Antimony	1.0	6	--	--	×	--	×
Arsenic	5.9	25	--	--	×	--	×
Barium	750	1,000	--	--	×	--	×
Beryllium	<1.0	4	--	--	×	--	×
Bismuth	<2.0	NV	NV	--	×	--	×
Boron	697	5,000	--	--	×	--	×
Cadmium	0.078	5	--	--	×	--	×
Calcium	149,000	NV	INT	--	×	--	×
Chromium	<1.0	50	--	--	×	--	×
Cobalt	**5.67**	**3**	**--**	--	✓	--	×*
Copper	3.6	1,000	--	--	×	--	×
Iron	**15,100**	**NV**	**300[B]**	**2,200[A]**	×	--	×*
Lead	1.0	10	--	--	×	--	×
Magnesium	215,000	NV	INT	--	×	--	×
Manganese	**14,500**	**NV**	**50[B]**	**64[A]**	×	--	×*
Mercury	**1.3 (0.022**)**	**1.0**	**--**	**--**	✓	**--**	**×***
Molybdenum	7	70	--	--	×	--	×
Nickel	10.2	100	--	--	×	--	×
Phosphorous	103	NV	INT	--	×	--	×
Potassium	46,200	NV	INT	--	×	--	×
Selenium	<1.0	10	--	--	×	--	×
Silver	<0.1	100	--	--	×	--	×
Sodium	**1,570,000**	**NV**	**200,000[B]**	--	✓	--	×*
Strontium	1750	NV	--	1,860[A]	×	--	×
Thallium	<0.1	2	--	--	×	--	×
Tin	<2.0	NV	--	1,860[A]	×	--	×
Titanium	<2.0	NV	--	100[C]	×	--	×
Uranium	1.8	20	--	--	×	--	×
Vanadium	4.6	6.2	--	--	×	--	×
Zinc	43.6	5,000	--	--	×	--	×

Note:
1 – Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario (2011). Groundwater Components for Potable Water Scenario (µg/L). Coarse Textured Soil. GW 1.
2 - Health Canada. Guidelines for Canadian Drinking Water Quality. Summary Table. December 2010
A – Mid-Atlantic Risk Assessment. Regional Screening Level (RSL) Tap water Supporting Table, November 2012. U.S. EPA RSL value divided by 5.
B – Guideline based on aesthetic objectives not health-based criteria (Health Canada, 2010)
C – British Columbia Water Quality (Nagpal, 1995)
INT – Inherently Non-Toxic
NV - No value provided in this source for this parameter
-- EPC not calculated as maximum Site concentration is less than the applicable guideline
* Not carried forward for further assessment as the groundwater is in exceedance of a drinking water guideline and groundwater is not used as a drinking water source at this Site. See above text for further explanation.
** This is the concentration of the reanalyzed sampled. As previously noted, the presence of sediment was noted in the groundwater samples collected in March 2013. The monitoring wells with the two highest concentrations of mercury were resampled in May 2013. The monitoring well with the maximum of 1.3 µg/L in March was resampled with a concentration of 0.022 µg/L (May 2013). Therefore, the elevated mercury values present at this site (March 2013 samples) are assumed to be a result of sediment collected with the groundwater.

4.1.1.3 Summary of COPCs

The following COPCs were identified during the Hazard Identification and will be carried forward in the HHRA:

- In soil
  - Benzene;
  - F1 and F2 PHC fractions;
  - Naphthalene;
  - Carcinogenic PAHs; and,
  - Lead.

No COPCs were identified in other environmental media at the Site that required further assessment in the HHRA.

4.1.2 Identification of Potential Receptors

Based on the current and anticipated future commercial land use, the human receptors expected at the Site are Commercial Workers (office), Dockyard Workers, Site Visitors, and Construction Workers.

The general public is not expected to use the Site for recreational purposes; the Site is fenced, and has restricted access and enforced security. In addition, the Site is located in an industrial region of St. John's, surrounded by industrial/commercial properties and roadways. No children are expected to visit, and there is no daycare present or anticipated on the Site.

The Site Worker is expected to spend 8 hours/day inside the future Site office tower. As the Site is completely covered in concrete and asphalt, exposure to outdoor soils is assumed to be essentially negligible. For the purpose of this HHRA, the Site Worker was considered to be protective of security guard workers in the guardhouse if it is located within the proposed building.

The Dockyard Worker is expected to spend 8 hours/day outside working on the dock located on the property. As the Site is completely covered in concrete and asphalt, exposure to outdoor soils is assumed to be essentially negligible. For the purpose of this HHRA, the Dockyard Worker was considered to be protective of security guard workers in the guardhouse if it is located in an independent kiosk.

The Site Visitor is assumed to be an intermittent visitor to the Site (4 hours/day) and may include delivery persons or visiting professionals.

The Construction Worker is included as a receptor to assess any temporary worker on Site during possible future construction of buildings or earthworks. The Construction Worker is assumed to be outdoors on Site, for up to one year. It is possible that other personnel such as utility workers or consultants may work at the Site in the future. For the purposes of this HHRA, the Construction Worker was considered to be protective of these other receptors in that the Construction Worker will likely be in contact with environmental media to a greater degree than a utility worker or consultant such as a site assessor. In addition, the Construction Worker was consider to be protective of the Dockyard worker for any dust particles which may result from the earthworks during the construction of the office tower.

The physical characteristics (required for exposure calculations) are specific values employed for each receptor in this HHRA were obtained from Health Canada (2010a) and are represented in Table 4.9.

Table 4.9 Human Receptor Characteristics

Characteristic	Unit	Adult Site Worker, Dockyard Worker, and Site Visitor	Construction Worker
Age	Years	> 20	> 20
Age Group Duration	Years	60	60
Total Years Exposed (Working Years)	Years	35	35
Body Weight	Kg	70.7	70.7
Soil Ingestion Rate	g/d	0.02	0.1
Inhalation Rate	m^3/d	16.6	1.4 m^3/h [a]
Water Ingestion Rate	L/d	1.5	1.5
Skin Surface Area (Hands+ Arms)	cm^2	3390	3390
Skin Surface Area (Hands+ Arms+ Legs)	cm^2	9110	9110
Soil Loading (Hand)	g/cm^2/event	$1x10^{-4}$	$1x10^{-3}$
Soil Loading (Other)	g/cm^2/event	$1x10^{-5}$	$1x10^{-4}$

Note:
All Receptor characteristics were taken from Health Canada (2010a).
a-The Health Canada inhalation rate is provided in m^3/hr, and the more protective rate provided for males is used in this assessment.

4.1.3 Identification of Operable Exposure Pathways

Exposure pathways are used to describe how a substance can move from the impacted media (*e.g.,* soil) to a point where it can enter the body. Only those pathways for which there is a reasonable potential for exposure were considered quantitatively in this HHRA. It should be noted that EPCs are not used for the inhalation of indoor air, but rather the maximum measured concentration is used.

The likelihood of exposure includes consideration of the duration and frequency of exposure to COPCs. The likelihood that the identified receptors may be exposed to the identified hazards through the various exposure routes for the Site is qualitatively evaluated in Table 4.11 to Table 4.14. A graphic illustration of the pathways carried forward for assessment for the Site is provided in the Conceptual Site Model (CSM).

Table 4.10 Potential Exposure Scenarios for the Site Worker

Potential Exposure Route	Operable Pathway	Carried Forward	Justification
Dermal contact with soil Ingestion of soil Inhalation of soil particles	Unlikely	No	It is unlikely that Site receptors will come into contact with soils at the Site as the Site is completely covered in concrete and asphalt
Inhalation of soil vapours - indoor	Possible	Yes	There are no buildings present on Site. However, it is assumed that a commercial building (slab-on-grade) may be built in the future.
Inhalation of soil vapours - outdoor	Very Unlikely	No	The dilution of vapours in outdoor air would likely result in an essentially negligible risk from inhalation of outdoor vapours.
Dermal contact with sediment	Very Unlikely	No	Although a water feature is present along the northwest boundary of the Site; it is very unlikely that Site receptors would enter the water and be exposed to Site sediment as it is an urban harbour and is located at an active dock.
Ingestion of groundwater Dermal contact with groundwater	Very Unlikely	No	Potable groundwater is not available at the Site and no known potable groundwater sources are known at the Site. Therefore, it is very unlikely that Site receptors would ingest the groundwater. Potable water is supplied by the St. John's Municipality.
Inhalation of groundwater vapours	Possible	Yes	There are no buildings present on Site. However, it is assumed that a commercial building (slab-on-grade) may be built in the future.
Dermal contact with surface water Ingestion of surface water	Unlikely	No	Although a water feature is present along the northwest boundary of the Site; it is very unlikely that Site receptors would enter the water and be exposed to Site surface water as it is an urban harbour and is located at an active dock.
Ingestion of Site vegetation	Very Unlikely	No	Site receptors are unlikely to grow and eat vegetation at the Site.
Ingestion of wild game from the Site	Very Unlikely	No	Site receptors are unlikely to catch and eat wild game at the Site.
Ingestion of fish from the Site	Very Unlikely	No	Site receptors are unlikely to catch and eat fish at the Site.

Based on the potential exposure pathway analysis summarized in Table 4.11, the Site Worker would inhale indoor air vapours (from impacted soil and/or groundwater). The Site Worker is not expected to come into contact with soil or surface water (St. John's Harbour) at the Site.

Table 4.11 Potential Exposure Scenarios for the Dockyard Worker

Potential Exposure Route	Operable Pathway	Carried Forward	Justification
Dermal contact with soil Ingestion of soil Inhalation of soil particles	Very Unlikely	No	It is unlikely that Site receptors will come into contact with soils at the Site as the Site is completely covered in concrete and asphalt. During the time the building is being constructed, the Construction Worker is considered to be a surrogate for the inhalation of soil particles which the Dockyard Worker may be exposed to.
Inhalation of soil vapours - indoor	Very Unlikely	No	There are no buildings present on Site. It is assumed that a commercial building (slab-on-grade) may be built in the future; however, the Dockyard Worker is assumed to work outside for 8 hours/day.
Inhalation of soil vapours - outdoor	Very Unlikely	No	The dilution of vapours in outdoor air would likely result in an essentially negligible risk from inhalation of outdoor vapours.
Dermal contact with sediment	Very Unlikely	No	Although a water feature is present along the northwest boundary of the Site; it is very unlikely that Site receptors would enter the water and be exposed to Site sediment as it is an urban harbour and is located at an active dock.
Ingestion of groundwater Dermal contact with groundwater	Very Unlikely	No	Potable groundwater is not available at the Site and no known potable groundwater sources are known at the Site. Therefore, it is very unlikely that Site receptors would ingest the groundwater. Potable water is supplied by the St. John's Municipality.
Inhalation of groundwater vapours	Very Unlikely	No	There are no buildings present on Site. However, it is assumed that a commercial building (slab-on-grade) may be built in the future.
Dermal contact with surface water Ingestion of surface water	Very Unlikely	No	Although a water feature is present along the northwest boundary of the Site; it is very unlikely that Site receptors would enter the water and be exposed to Site surface water as it is an urban harbour and is located at an active dock.
Ingestion of Site vegetation	Very Unlikely	No	Site receptors are unlikely to grow and eat vegetation at the Site.
Ingestion of wild game from the Site	Very Unlikely	No	Site receptors are unlikely to catch and eat wild game at the Site.
Ingestion of fish from the Site	Very Unlikely	No	Site receptors are unlikely to catch and eat fish at the Site.

Based on the potential exposure pathway analysis summarized in Table 4.12, the Dockyard Worker is not expected to come into contact with soil, indoor air or surface water (St. John's Harbour) at the Site. The Dockyard Worker would inhale outdoor air vapours (from impacted soil and/or groundwater); however, the dilution of vapours in outdoor air would likely result in an essentially negligible risk from inhalation of outdoor vapours.

Table 4.12 Potential Exposure Scenarios for the Site Visitor

Potential Exposure Route	Operable Pathways	Carried Forward	Justification
Dermal contact with soil Ingestion of soil Inhalation of soil particles	Very Unlikely	No	It is unlikely that Site receptors will come into contact with soils at the Site as the Site is completely covered in concrete and asphalt.
Inhalation of soil vapours - indoor	Possible	Yes	There are no buildings present on Site. However, it is assumed that a commercial building (slab-on-grade) may be built in the future.
Inhalation of soil vapours - outdoor	Very Unlikely	No	The dilution of vapours in outdoor air would likely result in an essentially negligible risk from inhalation of outdoor vapours.
Dermal contact with sediment	Very Unlikely	No	Although a water feature is present along the northwest boundary of the Site; it is very unlikely that Site receptors would enter the water and be exposed to Site sediment as it is an urban harbour and is located at an active dock.
Ingestion of groundwater Dermal contact with groundwater	Very Unlikely	No	Potable groundwater is not available at the Site and no known potable groundwater sources are known at the Site. Therefore, it is very unlikely that Site receptors would ingest the groundwater. Potable water is supplied by the St. John's Municipality.
Inhalation of groundwater vapours	Possible	Yes	There are no buildings present on Site. However, it is assumed that a commercial building (slab-on-grade) may be built in the future.
Dermal contact with surface water Ingestion of surface water	Very Unlikely	No	Although a water feature is present along the northwest boundary of the Site; it is very unlikely that Site receptors would enter the water and be exposed to Site surface water as it is an urban harbour and is located at an active dock.
Ingestion of Site vegetation	Very Unlikely	No	Site receptors are unlikely to grow and eat vegetation at the Site.
Ingestion of wild game from the Site	Very Unlikely	No	Site receptors are unlikely to catch and eat wild game at the Site.
Ingestion of fish from the Site	Very Unlikely	No	Site receptors are unlikely to catch and eat fish at the Site.

Based on the potential exposure pathway analysis summarized in Table 4.13, the Site Visitor would inhale indoor air vapours (from impacted soil and/or groundwater). The Site Visitor is not expected to come into contact with soil or surface water (St. John's Harbour) at the Site.

Table 4.13 Potential Exposure Scenarios for the Construction Worker

Potential Exposure Route	Operable Pathways	Carried Forward	Justification
Dermal contact with soil	Possible	Yes	It is likely that Construction Workers will come into contact with soils at the Site.
Ingestion of soil			
Inhalation of soil particles			
Inhalation of soil vapours - indoor	Very Unlikely	No	There are no buildings present on Site. However, it is assumed that a commercial building (slab-on-grade) may be built in the future. It is unlikely that Construction Workers would spend any time inside Site buildings
Inhalation of soil vapours - outdoor	Very Unlikely	No	The dilution of vapours in outdoor air would likely result in an essentially negligible risk from inhalation of outdoor vapours. It is assumed that deep trenches will not be present on the site due to depth of groundwater and, if deep trenches are used, health and safety procedures should be implemented to ensure soil vapours are not of concern
Dermal contact with sediment	Very Unlikely	No	Although a water feature is present along the northwest boundary of the Site; it is very unlikely that Site receptors would enter the water and be exposed to Site sediment as it is an urban harbour and is located at an active dock.
Ingestion of groundwater	Very Unlikely	No	Potable groundwater is not available at the Site and no known potable groundwater sources are known at the Site. Therefore, it is very unlikely that Site receptors would ingest the groundwater. Potable water is supplied by the St. John's Municipality.
Dermal contact with groundwater	Possible	Yes	There are no buildings present on Site. However, it is assumed that a commercial building (slab-on-grade) may be built in the future. Therefore, dermal contact with groundwater during earthworks is possible. Groundwater depth was measured to be 0.5 to 2.42 m.
Inhalation of groundwater vapours	Very Unlikely	No	There are no buildings present on Site. However, it is assumed that a commercial building (slab-on-grade) may be built in the future. It is unlikely that Construction Workers would spend any time inside Site buildings
Dermal contact with surface water	Very Unlikely	No	Although a water feature is present along the northwest boundary of the Site; it is very unlikely that Site receptors would enter the water and be exposed to Site surface water as it is an urban harbour and is located at an active dock.
Ingestion of surface water			
Ingestion of Site vegetation	Very Unlikely	No	Site receptors are unlikely to grow and eat vegetation at the Site.
Ingestion of wild game from the Site	Very Unlikely	No	Site receptors are unlikely to catch and eat wild game at the Site.
Ingestion of fish from the Site	Very Unlikely	No	Site receptors are unlikely to catch and eat fish at the Site.

Based on the potential exposure pathway analysis summarized in Table 4.14, the Construction Worker would be exposed to Site soil via dermal contact, ingestion and inhalation of soil particles and dermal contact with groundwater.

4.1.4 Human Health Conceptual Site Model

The CSM constructed for this HHRA is presented as Figure 4-1. The CSM provides a simplified representation of potential exposure pathways, linking COPC concentration to the receptor.

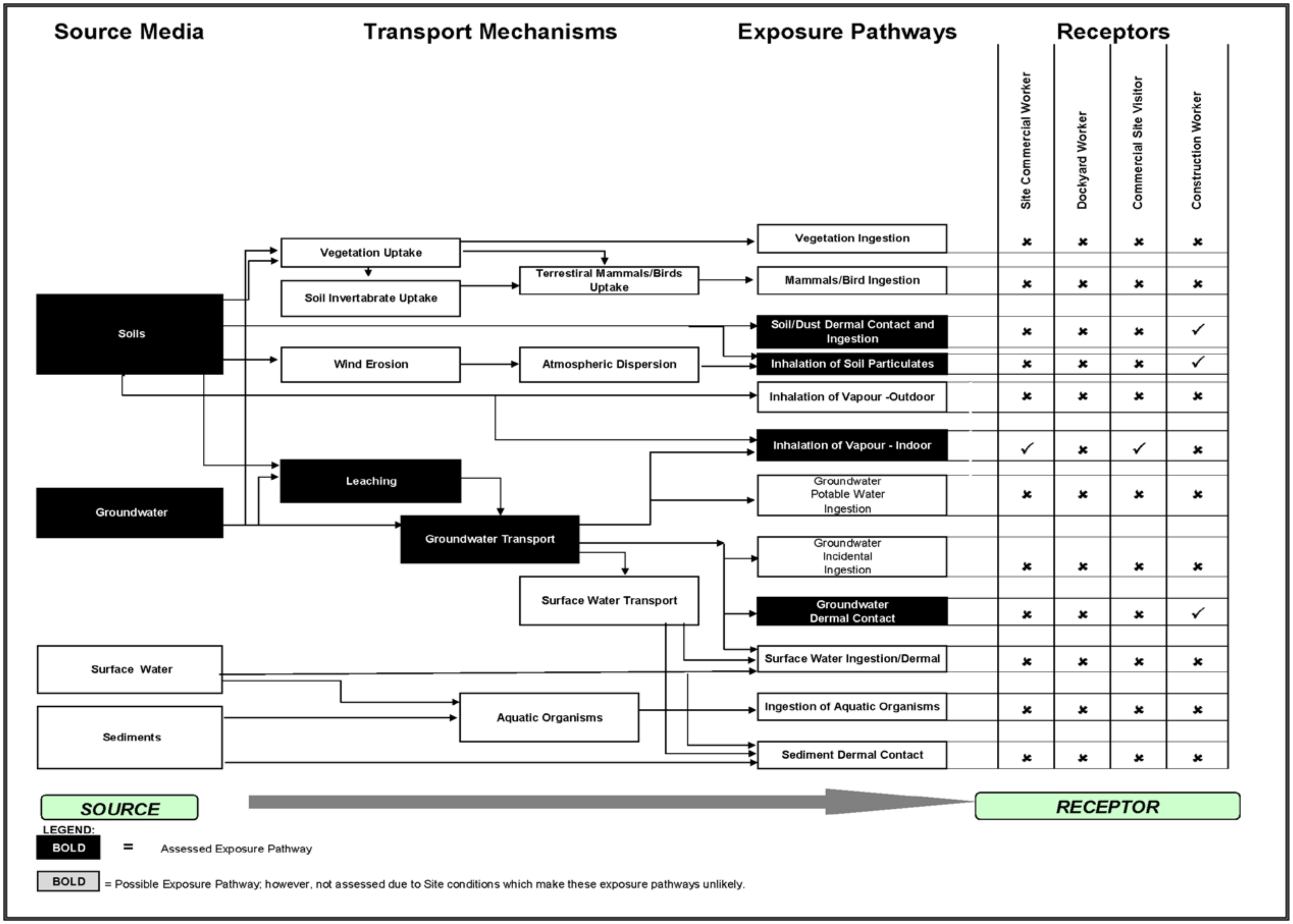

Figure 4-1 Human Health Conceptual Site Model

4.1.5 Exposure Frequency and Duration

To ensure the conservative nature of the HHRA, while remaining realistic, the Site Worker and Dockyard Worker was assumed to be on the Site 8 hours/day, 5 days/week, 52 weeks/year for 35 years. The Site Visitor was assumed to be on the Site 4 hours/day, 1 days/week, 52 weeks/year for 35 years. The Construction Worker was assumed to be on Site 10 hrs/day, 5 days/week for 13 weeks/year, for one year.

The exposure duration and frequency for each receptor at the Site is summarized in Table 4.14.

Table 4.14 Summary of Receptor Exposure Duration and Frequency by Receptor

Characteristic	Units	Site Worker	Site Visitor	Dockyard Worker	Construction Worker
Receptor		**Adult**	**Adult**	**Adult**	**Adult**
Hours per day on Site exposed to soil	h/d	8 [A]	4	8	10
Days per week on Site	d/w	5 [A]	1	5	5
Weeks per year on Site	w/y	52 [A]	52	52	13
Exposure Duration	y	35 [A]	35	35	1
Total Years Exposed (non-carcinogens)	y	35 [A]	35	35	1
Total Years Exposed (carcinogens)	y	35 [A]	35	35	1
Life Expectancy	y	80 [A]	80	80	80

Note:
A – Receptor exposure characteristics for the Site Worker taken directly from Health Canada (2010a); while exposure characteristics for other receptors adjusted, as required.

All exposure scenarios are either default exposure periods based on information from the Federal Contaminated Site Risk Assessment in Canada Part I: Guidance on Human Health enhanced PQRA document (HC 2010a) or values selected based on the professional judgment of the practitioner in consultation with representatives of the PWGSC. Hours per day on Site were based on average working hours, and days per week based on the average workweek (consistent with Health Canada), or using Site data provided by PWGSC representatives. Time spent on site consists of 1 year for a construction worker on a contracted project, and 35 years for long-term workers (estimated years of work).

4.2 Exposure Assessment

The Exposure Assessment estimates the interaction between the receptors and the COPC at the Site. The main objective of this assessment is to develop a quantitative estimate of exposure to each COPC for each receptor based on empirical data. The physical characteristics discussed in the receptor characterization section will be incorporated into the exposure assessment.

Daily intakes from all sources, as calculated using the Health Canada exposure equations, are discussed in the following sections and presented for the COPC carried forward. Ingestion rates and receptor characteristics (*e.g.,* body mass) were obtained from Health Canada (2010a).

4.2.1 Bioavailability

For all exposure calculations involving oral ingestion and inhalation of contaminated particles the absorption factors were set to a default of 100% or 1.0, as outlined in Health Canada guidance (2010b) with the exception of lead. As per guidance, a oral ingestion bioavailability value of 0.6 should be used for lead (MOE, 1994). In the case of dermal absorption of contaminants across the skin membrane, relative dermal absorption factors were adopted from Health Canada (2010b).

4.2.2 Exposure Equations

Health Canada's equations were used to determine non-carcinogenic HQs and carcinogenic ILCRs for this HHRA. Example calculations used can be found in the Health Canada DQRA and PQRA Guidance document (2010a; 2010c).

4.2.3 Exposure Point Concentrations

Exposure point concentrations provide an estimate of the concentration to which a Site receptor may realistically be exposed while at the Site. The use of an exposure point concentration provides a more realistic and Site specific estimate of the potential risks.

4.2.3.1 Soil

The soil concentrations used to represent exposure in this HHRA was the EPCs calculated for soil screening in Section 4.1.1.1. Therefore, a calculated EPC (95^{th} UCLM) was used for the direct contact pathway and the maximum was used (as the EPC) for indoor air pathways.

4.2.3.2 Dust or Airborne Particulate

The dust or airborne particulate concentrations used in the HHRA are calculated using the soil EPC multiplied by the average airborne concentration of respirable particulate matter. The average airborne concentration of respirable particulate matter was only calculated for the Construction Worker as this was the only receptor with an exposure pathway to particulate matter. Therefore, the average airborne concentration of respirable particulate matter for the Construction Worker, who may be exposed to elevated levels of dust comparable to those generated by vehicle traffic over an unpaved road during construction activities, was assumed to be 250 $\mu g/m^3$ (Health Canada, 2010a).

4.2.3.3 Indoor Air

For the purposes of the assessment of the potential risk posed by inhalation of indoor air in the future commercial building, indoor air vapour concentration were modeled using the Johnson and Ettinger (J&E) model for subsurface vapour intrusion into buildings. Default commercial building characteristics were selected to correspond to those used by the CCME in the derivation of the CWS for the vapour inhalation pathway guidelines (CCME, 2008), with the exception of building footprint (as this was provided from PWGSC). The CCME defaults values for commercial slab-on-grade buildings were selected because they represent federal guidance for the derivation of petroleum hydrocarbon indoor vapour intrusion guidelines, allowing this HHRA to remain consistent with the selected screening guidelines.

To model the indoor air vapour concentration in the possible future commercial buildings, the CCME (2008) equations and default parameters specified for a commercial slab on grade building was used.

4.3 Toxicity Assessment

Toxic effects from exposure to environmental contaminants vary depending on the form of the contaminant (such as dissolved, or sorbed to soil), the dosage, the route (*e.g.,* ingestion, inhalation, or dermal exposure), the frequency and duration of exposure, and the physiological state, sex, and age of the exposed population. Toxicological effects may be brief or prolonged, reversible or irreversible, immediate or delayed. The purpose of a toxicity assessment is to weigh available evidence regarding the potential for the environmental contaminants to cause adverse effects in exposed populations and to provide an estimate of the relationship between the extent of exposure and the increased likelihood and / or severity of those adverse effects.

An essential part of the risk assessment process is the identification of toxicity values against which exposures can be compared. These values are based on scientifically reviewed, published toxicological assessments from Canadian and American sources. Toxicity Reference Values (TRVs) have been established by several regulatory agencies including; Health Canada, the United States Environmental Protection Agency (US EPA); the World Health Organization (WHO); and the Agency for Toxic Substances and Disease Registry (ATSDR). In the selection of toxicity values, preference has been given to the Health Canada values as directed in the Health Canada Guidance document (2010b).

The chronic TRVs used in this HHRA are shown in Table 4.15.

Table 4.15 Chronic Toxicological Reference Values (TRVs) Used in this Assessment

COPC		Exposure Pathway	Chronic TRV	Effect/Target Organ	Reference
PHC F1 Fraction	Aliphatic C6-C8	Inhalation	18.4 mg/m^3	Neurotoxicity	CCME CWS 2008
	Aliphatic C8-C10	Inhalation	1 mg/m^3	Hepatic and hematological changes	
	Aromatic C8-C10	Inhalation	0.2 mg/m^3	Decreased body weight	

<table>
<tr><th colspan="2">COPC</th><th>Exposure Pathway</th><th>Chronic TRV</th><th>Effect/Target Organ</th><th>Reference</th></tr>
<tr><td rowspan="4">PHC F2 Fraction</td><td>Aliphatic C10-C12</td><td>Inhalation</td><td>1 mg/m^3</td><td rowspan="2">Hepatic and hematological changes</td><td rowspan="4">CCME CWS 2008</td></tr>
<tr><td>Aliphatic C12-C16</td><td>Inhalation</td><td>1 mg/m^3</td></tr>
<tr><td>Aromatic C10-C12</td><td>Inhalation</td><td>0.2 mg/m^3</td><td rowspan="2">Decreased body weight</td></tr>
<tr><td>Aromatic C12-C16</td><td>Inhalation</td><td>0.2 mg/m^3</td></tr>
<tr><td colspan="2">Benzene</td><td>Inhalation</td><td>0.0033 (mg/m^3)$^{-1}$</td><td>Hematoxicity</td><td>Health Canada 2010b</td></tr>
<tr><td colspan="2">Naphthalene</td><td>Inhalation</td><td>0.0037 mg/m^3</td><td>Nasal Effects</td><td>MOE 2011 & ATSDR 2005</td></tr>
<tr><td colspan="2">Carcinogenic PAHs</td><td>Ingestion</td><td>2.3 (mg/kg-d)$^{-1}$ (Benzo[a]pyrene)</td><td>Gastric Tumours</td><td>Health Canada 2010b</td></tr>
<tr><td colspan="2">Lead</td><td>Ingestion</td><td>0.00185 mg/kg</td><td>neurobehavioural development</td><td>MOE 1994</td></tr>
</table>

4.4 Risk Characterization

The purpose of the risk characterization is to combine the information from the toxicity assessment and the results of the exposure assessment to estimate the potential risks to human health from the COPC evaluated.

4.4.1 Non- Carcinogens

In general, the potential for adverse non-carcinogenic health effects is estimated by dividing the dose by the TRV (oral or inhalation, as applicable) for that COPC, as follows:

$$HQ = \frac{\text{Dose (mg/kg-d)}}{\text{TRV (mg/kg-d)}}$$

The computed ratio is termed the Hazard Quotient (HQ). In the absence of individual pathway TRVs (*i.e.,* inhalation TCs), the doses were summed and compared to the oral TRV. For the purposes of the HHRA, if the HQ is less than 0.2 (0.5 for TEX, F1 and F2), Health Canada considers that the intake of the COPC does not exceed the tolerable intake and negligible health risks are expected. Conversely, if the HQ exceeds 0.2 (0.5 for TEX, F1 and F2), Health Canada considers that there may be a potential risk to human health, and a more detailed assessment should be undertaken. For PAHs and metals, the HQ of 0.2 sets the upper limit of exposure from the Site to be equal to or less than 20% of the tolerable daily intake for a chemical, thus (protectively) allowing 80% of the exposure to be from additional sources.

For PHC F1 and F2 fractions, the CCME recommends comparing the Hazard Index (HI), which consists of the sum of the HQs for each aliphatic and aromatic subfraction (F1 and F2 is 0.5). The use of a HI accounts for the potential cumulative effects of exposure to several PHC subfractions simultaneously. If the F1 or F2 HI is less than 0.5, the health risk is considered negligible.

If the calculated hazard quotient for a COPC exceeds the target HQ, then a potential hazard exists and a maximum allowable concentration (*i.e.,* SSTL) is then calculated based on methods presented by CCME and Health Canada.

4.4.2 Carcinogens

The potential for carcinogenic health effects for each COPC in each exposure scenario is estimated by multiplying the carcinogenic dose by the carcinogenic TRV (oral or inhalation, as applicable) for that COPC, as follows:

$$\textbf{ILCR = Dose (mg/kg-d) x Oral Slope Factor (mg/kg-d)}^{-1}$$

The computed product is termed the Increased Lifetime Cancer Risk (ILCR). Increased Lifetime Cancer Risk for individual exposure pathways were presented where there were pathway specific TRVs. In the absence of individual pathway TRVs (*i.e.,* inhalation risk-specific concentrations), the doses were summed and compared to the oral TRV. For the purposes of the HHRA, if the ILCR is less than 1×10^{-5}, or 1 additional case of cancer in 100,000 people in a population, Health Canada considers that the intake of the COPCs by all routes of exposure does not exceed the tolerable intake and the risk is not considered unacceptable. Conversely, if the ILCR exceeds 1×10^{-5}, Health Canada considers that there may be an unacceptable cancer risk, and a more detailed assessment should be undertaken.

If the calculated ILCR for a COPC exceeds the target ILCR, then a potential hazard exists and a maximum allowable concentration (*i.e.,* SSTL) is then calculated based on methods presented by CCME and Health Canada.

4.4.3 Results of the Risk Characterization

4.4.3.1 Site Worker and Site Visitor

The Site Worker and Site Visitor are only exposed to COPCs via the indoor air. The results of the Risk Characterization are presented in Table 4.17. Calculations for HQs, showing exposure doses from each pathway for each receptor, are found in Appendix D. As per CCME guidance, the total Site ingestion and inhalation HQs are summed and compared to the benchmark of 0.5 because the inhalation and oral TRVs for the PHC sub-fractions are based on the same critical effects. The results of the risk assessment show that HQs from exposure to the Site do not pose an unacceptable risk for the Site Worker and Site Visitor for naphthalene and benzene (*i.e.,* HQ<0.2 for naphthalene, and ILCR<1.0×10^{-5} for benzene). However, the risk assessment does show the HQs for PHC fractions are greater than the acceptable limit for PHC F1 and F2 (*i.e.,* HQ>0.5 for PHC fractions).

Please note, the SSTLs calculated for benzene, PHC F1 and F2, and naphthalene were derived using soil data to model a predicted indoor air concentration. These modeled values are based on conservative assumptions of site conditions, and as such are expected to be higher than the actual indoor air concentrations of these parameters. Therefore, soil vapour data was collected for benzene, PHC F1 and F2, and naphthalene as part of the HHRA to further evaluate the potential for vapour intrusion into the proposed site building, and to provide a more realistic estimate of anticipated indoor air concentrations of these parameters in the proposed site building as a result of subsurface petroleum hydrocarbon impacted soil present on the property.

Table 4.16 Risk to the Site Worker and Site Visitor at the Site

Compound	Maximum Concentration (mg/kg)	Site Worker and Site Visitor		
		HQ (unitless)	ILCR (unitless)	SSTL (mg/kg)
Benzene	0.83	NA	3.53×10^{-6}	2.35
PHC F1	**1400**	**1.48**	**NA**	**474**
PHC F2	**24000**	**2.63**	**NA**	**4560**
Naphthalene	38	0.057	NA	134

Note:
Shaded/bolded - Maximum concentration exceeds SSTL.

4.4.3.2 Dockyard Worker

The Dockyard Worker is not exposed to any COPCs which required assessment because the Dockyard Worker is only exposed to outdoor air and as stated in Table 4.11, the dilution of vapours in outdoor air would likely result in an essentially negligible risk from inhalation of outdoor vapours.

4.4.3.3 Construction Worker

The Construction Worker is exposed to COPCs via the soil ingestion, soil inhalation and dermal contact pathways. The results of the Risk Characterization are presented in Table 4.17. Calculations for HQs, showing exposure doses from each pathway for each receptor, are found in Appendix D. As per Health Canada guidance, if the HQ is less than 0.2 (or ILCR less than 1.0×10^{-5}) it is considered that the intake of that COPC does not exceed the tolerable intake and negligible health risks are expected. Conversely, if the HQ exceeds 0.2 or the ILCR exceeds 1.0×10^{-5}, Health Canada considers that there may be a potential risk to human health, and a more detailed assessment should be undertaken. The results of the risk assessment show that HQs from exposure to the Site does not pose an unacceptable risk (HQ<0.2 for lead and ILCR<1.0×10^{-5} for B(a)P TPE) for the Construction Worker. Therefore, no unacceptable risk to the Construction Worker is expected on this Site.

Table 4.17 Risk to the Construction Worker at the Site

Compound	Maximum Concentration (mg/kg)	EPC (mg/kg)	Construction Worker	
			HQ	ILCR
B(a)P TPE	29.29	12	NA	1.23×10^{-6}
Lead	2700	480	0.19	NA

Note:
NA – Not Applicable

4.4.4 Soil Vapour Data

The unacceptable risk predicted from soil based on exposure to indoor air was determined based on SSTLs derived from modeled indoor air concentrations using soil data from the Site. As stated previously, these modeled concentrations are based on conservative assumptions of site conditions, and as such are expected to be higher than the actual indoor air concentrations. Therefore, soil vapour data was collected as part of the HHRA to further evaluate the potential for vapour intrusion into the proposed site building, and to provide a more realistic estimate of anticipated indoor air concentrations of these parameters in the proposed site building as a result of subsurface petroleum hydrocarbon impacted soil present on the property.

The soil vapour data was used to predict the concentration of COPCs in indoor air by applying a dilution factor. For this assessment, the dilution factor of 0.02 recommended for both the Residential and Commercial/Industrial setting in the Health Canada guidance (2010d) was used.

The results of the Risk Characterization from the soil vapour data are presented in Table 4.18. Concentrations used for the HQ calculations are found in Appendix D. As per CCME (2008) guidance, the F1 and F2 sub-fraction HQs are summed and compared to the benchmark of 0.5. As indicated in Table 4.18, the soil vapour concentrations in the sample from VP04 suggest a potentially unacceptable risk to benzene, PHC F1 and F2, as indicated by HQ/ILCR greater than the targets of 0.5 (HQ) and 1.0 x 10^{-5} (ILCR). Therefore, even when some of the conservatism in the HHERA is removed by using measured soil vapour data to predict indoor air concentration instead of using soil concentrations to predict indoor air concentration, a potential risk to benzene, PHC F1 and F2 is still indicated at this site.

Table 4.18 Indoor Inhalation Risk Based on Soil Vapour Data

Parameter	Target	Soil Vapour	Soil Vapour	Soil Vapour	Soil Vapour
	HQ/ILCR	VP01	VP02	VP03	VP04
Carcinogenic					
Benzene	1.00E-05	6.69E-08	2.89E-07	2.13E-06	**2.88E-05**
Non Carcinogenic					
Toluene	0.5	8.04E-06	2.15E-05	1.04E-04	1.37E-03
Ethylbenzene	0.5	8.77E-06	7.29E-05	3.23E-04	1.33E-02
Xylenes	0.5	1.58E-04	2.04E-03	6.30E-03	2.44E-01
Total PHC F1	**0.5**	**4.82E-04**	**4.36E-03**	**9.30E-02**	**8.24E-01**
PHC F1 – Aliphatic >C_5-C_6	-	3.78E-06	4.29E-06	1.72E-04	8.91E-03
PHC F1 – Aliphatic >C_6-C_8	-	1.50E-05	1.79E-05	1.40E-03	2.45E-02
PHC F1 – Aliphatic >C_8-C_{10}	-	2.14E-04	5.70E-04	7.56E-02	3.41E-01
PHC F1 – Aromatic >C_7-C_8 (TEX Excluded)	-	6.85E-05	6.85E-05	6.85E-05	6.85E-05
PHC F1 – Aromatic >C_8-C_{10}	-	1.81E-04	3.70E-03	1.57E-02	4.49E-01

Parameter	Target	Soil Vapour	Soil Vapour	Soil Vapour	Soil Vapour
	HQ/ILCR	VP01	VP02	VP03	VP04
Total PHC F2	**0.5**	**1.87E-03**	**1.12E-02**	**2.70E-01**	**7.03E-01**
PHC F2 – Aliphatic $>C_{10}$-C_{12}	-	6.47E-04	1.05E-03	1.38E-01	1.86E-01
PHC F2 – Aliphatic $>C_{12}$-C_{16}	-	8.55E-04	1.10E-03	3.10E-02	1.92E-02
PHC F2 – Aromatic > C_{10}-C_{12}	-	2.30E-04	7.86E-03	5.67E-02	4.82E-01
PHC F2 – Aromatic > C_{12}-C_{16}	-	1.37E-04	1.17E-03	4.52E-02	1.56E-02

4.5 Assumptions and Uncertainty Analysis

Risk estimates normally include an element of uncertainty, and generally these uncertainties are addressed by incorporating conservative assumptions in the analysis. As a result, risk assessments tend to overstate the actual risk. Although many factors are considered in preparation of a risk analysis, analysis results are generally only sensitive to very few of these factors. The uncertainty analysis is included to demonstrate that assumptions used are conservative, or that the analysis result is not sensitive to the key assumptions.

A risk assessment containing a high degree of confidence will be based on:

- conditions where the problem is defined with a high level of certainty based on data and physical observations;
- an acceptable and reasonable level of conservatism in assumptions which will ensure that risks are overstated; or,
- an appreciation of the bounds and limitations of the final solution.

The exposure assessment performed as part of this study was based on:

- available data to describe existing surface soil conditions;
- sound conservative assumptions for certain parameters, as required; and,
- well understood and generally accepted methods for risk prediction.

4.5.1 Uncertainties in Toxicological Information

There is a very limited amount of toxicological information on the effects associated with human exposures to low levels of chemicals in the environment. What human information is available is generally based on epidemiological studies of occupationally exposed workers. These studies are generally limited in scope and provide results that may not be applicable to chronic or continuous exposures to low levels of chemicals. Because human toxicological information is limited, reference doses for many compounds are based on the results of dose-response assessment studies using animals.

The use of experimental animal data to estimate potential biological effects in humans introduces uncertainties into the evaluation of potential human health effects. These estimations require that a number of assumptions be made:

- The toxicological effect reported in animals is relevant and could occur in humans.
- The assumption that extrapolation from high-dose studies to low-dose environmental exposures adequately represents the shape of the dose-response curve in the low-dose exposure range.
- Short-term exposures used in animal studies can be extrapolated to chronic or long-term exposures in humans.
- The uptake of a compound from a test vehicle (*e.g.,* drinking water, food) in animals will be the same as the uptake of the chemical from environmental media (soil or air-borne particulate matter) in humans.

There are a number of uncertainties associated with extrapolating from experimental animal data to humans. To address these weaknesses, regulatory agencies, such as Health Canada and the US EPA, incorporate a large number of conservative assumptions to try and account for the uncertainties associated with this process. The uncertainties are accounted for by the use of Uncertainty Factors that are used to lower the reference dose well below the level at which adverse health effects have been reported in the test species. Uncertainty factors are generally applied by factors of 10 and are used to account for the following types of uncertainties:

- variation within the population (protection of sensitive members of the population);
- differences between humans and the test species;
- differences in using short or medium-term studies to estimate the health effects associated with long-term or chronic exposures; and,
- limitations in the available toxicological information.

The magnitude of the uncertainty factors applied by the various regulatory agencies provides an indication of the level of confidence that should be placed in the reference value. Uncertainty factors typically range between 100 and 10,000, although some can be lower than 10. The lowest uncertainty values, those less than 10, are found for a few chemicals where sound and substantial human toxicological information is available to enable the setting of toxicological end-point solely on the basis of human epidemiological information.

The application of uncertainty factors is intended to introduce a high degree of conservatism into the risk assessment process and to ensure, as far as possible, that limited exposures that exceed the reference concentrations will not result in adverse human health effects. Because risk assessments that use these regulatory limits incorporate the conservatism used in the development of the toxicological information, the results can generally be viewed as being extremely conservative.

4.5.2 Modeling Assumptions

Table 4.19 contains a summary of the assumptions used in this risk analysis, providing an evaluation for each assumption and an opinion as to whether the assumption is acceptable.

Table 4.19 Evaluation of the Assumptions in the Risk Analysis

Risk Analysis Study Factor/Assumption	Justification	Analysis Likely to Over/Under Estimate Risk?	Acceptable Assumption?
Hazard Identification			
Screening of potential chemicals of concern against human health-specific CCME guidelines.	Generic guidelines by nature are very conservative in order that they can be reliably applied to any situation, potentially with little Site-specific information available. Substances present at concentrations equal to or below human health guidelines are unlikely to be of concern.	Neutral	Yes
Exposure to surface soil based on EPC (95th UCLM for direct contact and maximum for indoor air).	Using this methodology the receptor is assumed to be exposed to concentrations that are representative of an upper bound on the mean of the Site concentrations for direct contact and maximum for indoor air. This choice results in a conservative assessment of the risk posed by exposure to the entire Site.	Over Estimate	Yes
Receptor Characteristics			
The Construction Worker and Commercial Worker were assumed to be adults for non-carcinogenic COPC.	This assumption is consistent with accepted practice from Health Canada and the US EPA.	Neutral	Yes
Exposure times durations were based on the default Health Canada (2010a) values for the potential future scenarios associated with construction of a new office building.	The exposure times represent a realistic estimate of Site exposures and durations for the current land use, and acceptable exposure and duration estimates for the potential future land use.	Neutral	Yes
Toxicity Information			
Most current toxicity information available from Health Canada, the CCME, and ATSDR was employed.	This approach is in accordance with standard practice and provides the most recent scientific basis for toxicity values. All values are extensively peer reviewed and accepted by Health Canada and/or the US EPA.	Neutral	Yes
Risk Characterization			
Where exposures were intermittent, or for a duration of less than 13 weeks / year, the exposures were not amortized to be protective of acute and sub-chronic exposures.	Amortizing sub-chronic or acute exposures over a longer period may result in an underestimate of risk during exposure	Neutral	Yes
Target Hazard Quotient = 0.2 for all COPC, with the exception of TEX and PHCs, where the Target Hazard Quotient = 0.5	This approach recognizes the contributions from all sources and provides the best estimate of total daily exposures. CCME guidelines assume that guidelines may also have to be established for other contaminated media at a Site (*e.g.,* water).	Neutral	Yes

4.6 Discussion and Recommendations

The results of the chemical screening indicate that there are COPCs in soil that required further consideration in the HHRA. In soil, benzene; PHC fractions (F1 and F2), carcinogenic PAHs, and lead were identified as the COPCs that were carried into the HHRA for further assessment. The Site Worker and Site Visitor will not be exposed to soil as the area is covered in asphalt and concrete; therefore, the indoor air pathway and the concentrations of benzene and PHC fractions (F1 and F2) were assessed for the Site Worker and Site Visitor. Lead was not of concern to the Site Worker and Site Visitor as this chemical is not considered to be volatile. The SSTLs calculated for the Site Worker and Site Visitor using the soil data (*i.e.,* benzene SSTL = 2.35 mg/kg, PHC F1 SSTL = 474 mg/kg and F2 SSTL = 4,560 mg/kg) were greater than the maximum concentration on site with the exception of the PHC fractions (F1 and F2). However, as stated previously, these SSTLs were derived using soil data to model a predicted indoor air concentration. These modeled values are based on conservative assumptions of site conditions, and as such are expected to be higher than the actual indoor air concentrations of these parameters. Therefore, soil vapour data was collected as part of the HHRA to further evaluate the potential for vapour intrusion into the proposed site building, and to provide a more realistic estimate of anticipated indoor air concentrations of the COPCs in the proposed site building as a result of subsurface petroleum hydrocarbon impacted soil present on the property. The results of the soil vapour sampling program supported the HHRA findings, and show that unacceptable risk may be present at the site for a Site Worker and Site Visitor (*i.e.,* building occupant) exposed to F1 and F2 PHC fractions and benzene via inhalation of indoor air with the concentrations in soil vapour sample VP04 having predicted HQ/ILCRs greater than the target HQ/ILCR.

The Construction Worker will be exposed to soil as it is assumed that there will be earthwork activity during the construction of the proposed office building. As a result, the construction worker will be exposed to the lead and PAH concentrations in the soil. However, the HQs calculated for the Construction Worker were less than the threshold of 0.2 for lead and PAHs. Therefore, the concentrations of lead and PAH in the soil should not result in unacceptable risk. The indoor air pathway does not apply to the Construction Worker. In conclusion, no unacceptable risk to the Construction Worker is expected on Site as a result of chemicals in soil.

All chemical concentrations in groundwater were within acceptable limits and no unacceptable risk is expected as a result of exposure to groundwater on the Site.

5.0 ECOLOGICAL RISK ASSESSMENT

The purpose of this ecological risk assessment (ERA) is to evaluate the potential that ecological receptors (*e.g.,* mammals, birds, plants, invertebrates) may experience toxicologically induced changes in ecological health as a result of exposure to COPCs found at the Site. As with the HHRA, this ERA is conducted following a widely recognized framework that progresses from a qualitative initial phase (Problem Formulation), through exposure and toxicity (effects) analysis, and culminates in a quantitative Risk Characterization. Following this, a discussion of the uncertainties inherent to the ERA, and conclusions and recommendations stemming from the assessment are discussed. The risk assessment methodology for this ERA uses guidance from the following documents:

- A Framework for Ecological Risk Assessment (General Guidance) (CCME, 1996);
- A Framework for Ecological Risk Assessment (Technical Appendices) (CCME, 1997);
- FCSAP Ecological Risk Assessment Guidance (Environment Canada, 2012a)
- Guidelines for Ecological Risk Assessment (U.S. EPA, 1998);
- Guidance for Conducting Ecological Risk Assessments (Ohio EPA, 2008); and,
- Rationale for the Development of Soil and Ground Water Standards for use at Contaminated Sites in Ontario (MOE, 2011);

5.1 Problem Formulation

The objective of the Problem Formulation stage of the ERA is the development of a focused understanding of how COPCs can affect the health of ecological receptors living in, or frequenting the Site. The main points addressed in the Problem Formulation are as follows:

- COPC Screening;
- Ecological Receptor Identification; and,
- Exposure Pathway Screening.

Results of the above screening processes are presented as an ecological conceptual site model (ECSM), which is a visual depiction of the relevant pathways linking COPCs in various environmental media and biota to the VECs evaluated in the ERA.

5.1.1 Chemicals of Potential Concern

Chemicals of potential concern (COPCs) are those compounds present at a site with the potential to impose adverse ecological effects under certain conditions (*i.e.,* if present at sufficient quantities and available to sensitive species). The maximum concentrations of measured COPCs in soil and groundwater were initially screened against applicable Canadian Council of Ministers of the Environment (CCME) environmental quality guidelines for commercial land use (CCME, 2010) and CCME Canada-Wide Standards (CWS) for PHC in Soil (CCME, 2008) as applicable. The maximum concentrations measured in groundwater were initially screened against Federal Interim Groundwater Quality Guidelines for Federal Contaminated Sites (EC, 2012b). In cases where no CCME or EC guidelines were available, other applicable standards/guidelines (*e.g.,* Ontario MOE, U.S. EPA) were used as a generic screening criterion. Chemicals were the maximum concentrations measured exceed applicable guidelines were considered to be COPCs for the ERA. Once the COPCs have been identified, a secondary screening was completed by comparing the exposure point concentration (calculated as an upper confidence limit on the mean) to the CCME guidelines for dermal contact.

The use of an upper confidence limit on the mean (UCLM) is more representative of the COPC concentrations that are present across the Site as a whole and provides a more realistic estimate of the reasonable exposure for a receptor moving across the Site over numerous visits for direct contact pathways. The UCLM is a statistical representation of the upper bound of the average concentration of COPC within the impacted portion of the Site. To determine the appropriate UCLM, the program ProUCL ® (Version 4.1.0 by U.S. EPA) was used and the UCLM recommended by ProUCL ® was selected. However, the UCLM can only be calculated for those chemicals for which the number of detected values in the dataset was sufficiently large (*i.e.,* greater than 8-10 detected values), as per US EPA (US EPA, 2010). In this case, the 95th percentile of the data distribution was used as the EPC (as per Health Canada, 2010c) to be screened against the applicable guideline.

5.1.1.1 Soil

Soil samples collected by Stantec in 2013 (*Stantec Report No. 121412551, Phase II Environmental Site Assessment, Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL*) make up the dataset considered in this ERA. The MGI petroleum hydrocarbon data collected in 2001 was not quantitatively used in this ERA due to the possibility that this data, which are over 12 years old, may not be representative of current site conditions. It is common practice in ERAs, and regulated in some jurisdictions (*e.g.,* Ontario), that where sufficient newer data is available that the newer data would supersede the older data. In addition, the soil samples collected by Stantec in 2013 are from across the Site and are located in areas where MGI data was collected in 2001. Therefore, the soil samples collected by Stantec in 2013 are considered to be representative of the current site conditions. Soil samples were obtained on the Site from a depth between 0 m to 6.3 m (n=20); however, only soil samples to a depth of 1.5 m were considered in the ERA (n=7). This depth was selected because soil at depths greater than 1.5 m are generally considered below the main rooting and feeding zones of most plants and wildlife species (CCME, 2008).

Petroleum Hydrocarbons

The screening values and maximum soil concentrations of BTEX and PHC fractions are presented in Table 5.1. All measured maximum soil concentrations of BTEX and PHC fractions are less than the applicable guideline. Therefore, petroleum hydrocarbons will not be assessed further in the ERA. PHC F4 is not assessed as part of the PHC group given its inherent lack of mobility and availability.

Table 5.1 Ecological Health Screening - Soil (PHC)

COPC	Maximum Concentration (mg/kg)	Ecological Guideline (mg/kg)	Maximum > Guideline	EPC	Carried Forward ?
Benzene	0.03	180 A	×	--	×
Toluene	0.056	300 A	×	--	×
Ethylbenzene	<0.025	250 A	×	--	×
Xylenes, Total	0.079	350 A	×	--	×
PHC F1 (C6-C10) - BTEX	7.1	320 B	×	--	×
PHC F2 (C10-C16 Hydrocarbons)	66	260 B	×	--	×
PHC F3 (C16-C34 Hydrocarbons)	135	1700 B	×	--	×

Note:
A – CCME Canadian Soil Quality Guidelines for the protection of Environmental and Human Health. Commercial Land Use; Coarse Textured Soil.
B – CCME Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil, 2008 – Commercial land use, coarse textured soil.
NV - No value provided in this source for this parameter
-- EPC not calculated as maximum site concentration is less than the applicable guideline

Polycyclic Aromatic Hydrocarbons (PAHs)

The screening values and maximum soil concentrations of polycyclic aromatic hydrocarbons (PAHs) are presented in Table 5.2. The maximum soil concentrations of PAHs were screened against the commercial ecological values in the CCME SQG_E. The maximum PAH (or EPC) concentrations are all less than the applicable guideline with the exception of naphthalene and phenanthrene. Therefore, only naphthalene and phenanthrene were carried forward for further assessment in the ERA.

Table 5.2 Ecological Health Screening - Soil (PAHs)

COPC	Maximum Concentration (mg/kg)	Ecological Guideline (mg/kg)	Maximum > Guideline	EPC	Carried Forward?
Acenaphthene	1.3	96 B	×	--	×
Acenaphthylene	0.078	9.6 B	×	--	×
Anthracene	2.2	32 A	×	--	×
Benzo(a)anthracene	4	10 A	×	--	×
Benzo(a)pyrene	2.4	72 A	×	--	×
Benzo(b)fluoranthene	1.7	10 A	×	--	×
Benzo(g,h,i)perylene	1.0	13 B	×	--	×
Benzo(b)fluoranthene	1.1	10 A	×	--	×
Benzo(k)fluoranthene	1.1	10 A	×	--	×
Chrysene	4.0	14 B	×	--	×
Dibenzo(a,h)anthracene	0.32	10 A	×	--	×
Fluoranthene	9.3	180 A	×	--	×
Fluorene	1.4	62 B	×	--	×

COPC	Maximum Concentration (mg/kg)	Ecological Guideline (mg/kg)	Maximum > Guideline	EPC	Carried Forward?
Indeno(1,2,3-cd)pyrene	0.95	10 [A]	×	--	×
1-Methylnaphthalene	0.34	29 [C]	×	--	×
2-Methylnaphthalene	0.42	29 [C]	×	--	×
Naphthalene	0.58	0.013 [A]	✓	0.496*	✓
Perylene	0.49	1.1 [C]	×	--	×
Phenanthrene	11	0.046 [A]	✓	7.885*	✓
Pyrene	7.1	100 [A]	×	--	×

Note:
A – CCME Canadian Soil Quality Guidelines for the protection of Environmental and Human Health. Commercial Land Use; Coarse Textured Soil.
B –Ontario Ministry of the Environment Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Sites in Ontario. 2011. Table 3, Full Depth Non-Potable Water Scenario for coarse grained soils. Commercial Land Use. Lowest of the ecological values.
C - U.S. EPA Ecological Soil Screening Level (Eco-SSL), lowest of plant, soil invertebrate or mammal value.
* 95 Percentile

Polychlorinated Biphenyls (PCBs)

The screening values and maximum soil concentrations of polychlorinated biphenyls (PCBs) are presented in Table 5.3. The maximum soil concentrations of PCBs were screened against the commercial ecological values in the CCME SQG_E. The maximum PCBs concentration is less than the CCME SQG_E; therefore, PCBs were not carried forward for further assessment in the ERA.

Table 5.3 Ecological Health Screening - Soil (PCBs)

COPC	Maximum Concentration (mg/kg)	CCME SQG_E [A] (mg/kg)	Carried Forward?
Polychlorinated Biphenyls (PCBs)	<0.05	33	×

Note:
A – CCME Canadian Soil Quality Guidelines for the protection of Environmental and Human Health. Commercial Land Use; Coarse Textured Soil.

Inorganic Parameters

Maximum Site soil concentrations and screening criteria for inorganic parameters are presented in Table 5.4. The inorganic elements had maximum soil concentrations less than the applicable guideline or no guideline was available (Table 5.4) except for manganese. Therefore, manganese is the only inorganic element carried forward for further assessment in the ERA.

- The maximum site aluminum concentration in soil was 14,000 mg/kg which is within the typical range of soil aluminum concentrations, ranging from 10,000 to 30,000 mg/kg (U.S. EPA, 2003).
- Iron was not carried forward for further assessment because it is a commonly occurring metallic element and the maximum soil iron concentration on Site was 29,000 mg/kg

which is within the typical range of iron concentrations in soil, ranging from 20,000 to 550,000 mg/kg (U.S. EPA, 2003). In addition, iron is essential for plant growth, and is generally considered to be a micronutrient.

- No ecological health screening values were available for strontium in any of the guidance used in this ERA. Therefore, strontium was not carried forward in this ERA.

Table 5.4 Ecological Health Screening - Soil (Inorganics)

COPC	Maximum Concentration (mg/kg)	Ecological Guideline (mg/kg)	Maximum > Guideline	EPC	Carried Forward?
Aluminum	14,000	Background Range – 10000 to 30000 [C]	×	--	×
Antimony	<2	20 [B]	×	--	×
Arsenic	5	26 [A]	×	--	×
Barium	45	670 [B]	×	--	×
Beryllium	<2	4 [B]	×	--	×
Boron	<5	120 [B]	×	--	×
Cadmium	<0.3	22 [A]	×	--	×
Chromium	24	87 [A]	×	--	×
Cobalt	11	40 [B]	×	--	×
Copper	25	91 [A]	×	--	×
Iron	29,000	Background Range – 20000 to 550000 [C]	×	--	×
Lead	32	600 [A]	×	--	×
Manganese	**880**	**220 [D]**	**✓**	**871***	**✓**
Mercury	<0.1	50 [A]	×	--	×
Molybdenum	<2	6.9 [B]	×	--	×
Nickel	18	50 [A]	×	--	×
Selenium	<1	2.9 [A]	×	--	×
Silver	<0.5	20 [B]	×	--	×
Strontium	30	NV	×	--	×
Thallium	<0.1	3.6 [A]	×	--	×
Tin	4	300 [E]	×	--	×
Uranium	1	2000 [A]	×	--	×
Vanadium	26	130 [A]	×	--	×
Zinc	82	360 [A]	×	--	×

Note:
A – CCME Canadian Soil Quality Guidelines for the protection of Environmental and Human Health. Commercial Land Use; Coarse Textured Soil.
B –Ontario Ministry of the Environment Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Sites in Ontario. 2011. Table 3, Full Depth Non-Potable Water Scenario for coarse grained soils. Commercial Land Use. Lowest of the ecological values
C – U.S. EPA 2003. Ecological Soil Screening Levels
D – U.S. EPA 2007. Ecological Soil Screening Levels
E – Alberta Tier 1 Soil and Groundwater Remediation Guidelines. 2012. Table A-5. Surface Soil Remediation Guideline Values for Commercial and Industrial Land Use – Direct Soil Contact.
NV - No value provided in this source for this parameter
-- EPC not calculated as maximum site concentration is less than the applicable guideline.
* 95 Percentile
Shaded and bold – carried forward for further assessment.

5.1.1.2 Groundwater

Groundwater samples (n=10) were collected by Stantec in March 2013. The maximum chemical concentration in groundwater on site was compared to the Federal Interim Groundwater Quality Guidelines (FIGQG) for Federal Contaminated Sites (EC, 2012b). Where no FIGQG exists, or in the cases where there is a guideline but it is based on a CCME interim value for the protection of aquatic life (where the derivation is unknown or not based on recent science), groundwater concentrations were compared to the MOE Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Sites in Ontario. 2011. Table 9; Groundwater Components for Within 30 m of a Water Body, Non-Potable Water Scenario, GW3 Pathway (MOE, 2011). The GW3 value is protective of aquatic life exposed to groundwater that is located within 30m of a water body. It is acknowledged that the GW3 values are derived for freshwater and not for marine; however, in the absence of a marine-derived guideline, a freshwater guideline was used. All COPCs with non-detectable concentrations and no available guideline or standard were not carried forward into the risk assessment. It was assumed that these compounds were not present on site in concentrations that would pose adverse health effects to ecological receptors.

Petroleum Hydrocarbon (PHCs)

The screening values and maximum groundwater concentrations of BTEX and PHC fractions are presented in Table 5.5. The maximum BTEX and PHC fraction groundwater concentrations were all less than analytical detection limits which, in turn, were less than the applicable guidelines. Consequently, no BTEX or PHC fractions were carried forward into the ERA for further assessment.

Table 5.5 Ecological Health Screening - Groundwater (PHC)

COPC	Maximum Concentration (mg/L)	$FIGQG_{Eco}$[1] (mg/L)	Maximum > Guideline	EPC	Carried Forward?
Benzene	0.016	0.2	×	--	×
Toluene	0.0038	8.9	×	--	×
Ethylbenzene	0.067	11	×	--	×
Xylenes, Total	0.12	18	×	--	×
F1 (C6-C10) - BTEX	1.21	9.8	×	--	×
F2 (C10-C16 Hydrocarbons)	1.25	1.3	×	--	×
F3 (C16-C34 Hydrocarbons)	0.63	NA	×	--	×

Note:
1 – Guidance Document on Federal Interim Groundwater Quality Guidelines for Federal Contaminated Sites; Commercial Land-Use – Marine life guideline was used where available. A Freshwater life value was used where no Marine Life guideline was available.
NA – Not Applicable
-- EPC not calculated as maximum site concentration is less than the applicable guideline

Polycyclic Aromatic Hydrocarbon (PAHs)

Many of the PAHs tested had maximum groundwater concentration greater than the applicable guidelines (Table 5.6). Consequently, PAHs required further assessment. However, during the sample collection of the groundwater samples in March 2013 by Stantec (reported in Stantec report in May, 2013a), sediment was noted in the samples. As a result, the concentrations of PAHs may be elevated due to the presence of sediment and do not reflect dissolved concentrations present in the groundwater. To determine if the elevated concentrations noted above are a result of sediment, the two monitoring wells with the highest concentrations of PAHs were resampled in May 2013. The results indicated that concentrations in all groundwater samples (May 2013 data, reported by Stantec in June (2013b)) were below the detection limit with the exception of fluoranthene (0.019 µg/L), phenanthrene (0.025 µg/L) and pyrene (0.017 µg/L). However, the detected concentrations of fluoranthene, phenanthrene and pyrene were less than the applicable guideline. From the results collected in May 2013 (from the most highly impacted wells (as indicated by the March 2013 data)), it is assumed that elevated concentrations in the other groundwater samples collected in March 2013 were also a result of sediment in the groundwater samples. As a result, elevated concentrations of PAHs measured in March 2013 are assumed to be a result of sediment in the sample and not dissolved PAHs in the groundwater. Therefore, PAHs will not be carried forward for further assessment.

Table 5.6 Ecological Health Screening - Groundwater (PAHs)

COPC	Maximum Concentration (µg/L)	FIGQGEco[1] (µg/L)	Max > Guideline?	Maximum of Reanalysis (May 2013) (µg/L)	Carried Forward?
1-Methylnaphthalene	13	180	×	<0.050	×
2-Methylnaphthalene	4.4	180	×	<0.050	×
Acenaphthene	4.5	5.8	×	<0.010	×
Acenaphthylene	0.74	46	×	<0.010	×
Anthracene	9.1	0.012	✓	<0.010	×
Benzo(a)anthracene	12	0.018	✓	<0.010	×
Benzo(a)pyrene	7.9	0.015	✓	<0.010	×
Benzo(b)fluoranthene	5.4	0.48	✓	<0.010	×
Benzo(g,h,i)perylene	3.8	0.17	✓	<0.010	×
Benzo(j)fluoranthene	3.4	0.48	✓	<0.010	×
Benzo(k)fluoranthene	3.2	0.48	✓	<0.010	×
Chrysene	11	1.4	✓	<0.010	×
Dibenzo(a,h,)anthracene	0.89	0.26	✓	<0.010	×
Fluoranthene	30	0.04	✓	0.019	×
Fluorene	6.6	3	✓	<0.010	×
Indeno(1,2,3-c,d) pyrene	2.9	0.21	✓	<0.010	×
Naphthalene	13	1.1	✓	<0.20	×

COPC	Maximum Concentration (µg/L)	FIGQGEco[1] (µg/L)	Max > Guideline?	Maximum of Reanalysis (May 2013) (µg/L)	Carried Forward?
Perylene	1.7	0.012*	✓	<0.010	×
Phenanthrene	35	0.4	✓	0.025	×
Pyrene	25	0.025	✓	0.017	×

Note:
1 – Guidance Document on Federal Interim Groundwater Quality Guidelines for Federal Contaminated Sites; Commercial Land-Use – Freshwater Life
* - No guideline was available for this PAH therefore the lowest PAH guideline was used

Polychlorinated Biphenyls

Data for PCBs are presented in Table 5.7. PCBs were not detected in groundwater and the detection limits were less than the applicable Ontario MOE water guideline. PCBs in groundwater were not carried forward for further assessment in the ERA.

Table 5.7 Ecological Health Screening - Groundwater (PCBs)

COPC	Maximum Concentration (µg/L)	MOE GW3 (µg/L)	Carried Forward?
Polychlorinated Biphenyls (PCBs)	<0.05	0.14	×

Note:
1 – Ontario Ministry of the Environment Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Sites in Ontario. 2011. Table 9; Commercial, Groundwater Components for Within 30 m of a Water Body, Non-Potable Water Scenario, GW3 Pathway.

Inorganic Parameters

Data for inorganic paramters are presented in Table 5.8. The maximum concentrations of aluminum, copper, and lead were greater than the applicable guidelines; therefore, these parameters were determined to be COPCs in groundwater. Next the exposure point concentrations (EPCs) for these COPCs (aluminum, copper, and lead) were screened against the applicable guidelines to determine if these COPCs needed to be assessed further in the ERA. It should be noted that the FIGQG for cadmium and mercury are based upon interim guidelines; therefore, the MOE GW3 value was used in the screening and the concentrations of cadmium and mercury were less than the GW3 value for within 30 m of a water body. In addition it should be noted (as previously discussed for PAHs above), that the groundwater samples collected in March 2013 were noted as having a presence of sediment during laboratory analysis. To determine if the elevated concentrations of mercury observed in the groundwater were a result of sediment content, the two monitoring wells with the highest concentrations of this parameter were resampled in May 2013. The resampling of the two wells with the highest concentrations of mercury resulted in mercury concentrations in groundwater that were less than the previous sampling event (March 2013) by an approximate factor of 100 and the concentrations were less than the applicable guideline. Therefore, the elevated concentration of mercury in groundwater was concluded to be a result of sediment in the collected samples. Based on these results, all inorganic COPCs were less than the applicable guideline or standards (Table 5.8), and therefore were not carried forward for further assessment in the ERA.

Table 5.8 Ecological Health Screening - Groundwater (Inorganics)

COPC	Maximum Concentration (µg/L)	FIGQG$_{Eco}$[1] (µg/L)	GW3[2] (µg/L)	Other	Maximum > Guideline	EPC	Carried Forward?
Aluminum	861	NV	NV	750[A]	✓	400	×
Antimony	2.8	2000			×	--	×
Arsenic	<1	12.5			×	--	×
Barium	136	500			×	--	×
Beryllium	<1	100			×	--	×
Bismuth	<2	NV			×	--	×
Boron	76	NV	45000		×	--	×
Cadmium	0.242	0.12*	2.7		×	--	×
Calcium	18300	NV	NV	Inherently Non-Toxic	×	--	×
Chromium	<1	56			×	--	×
Cobalt	5.47	NV	66		×	--	×
Copper	102	NV	87		✓	53.6	×
Iron	4500	300			✓	235	×
Lead	3.14	NV	25		×	--	×
Magnesium	5450	NV	NV	Inherently Non-Toxic	×	--	×
Manganese	319	NV	NV	1000 [B]	×	--	×
Mercury	1.3	0.016*	7.7		×	0.022**	×***
Molybdenum	3.4	73			×	--	×
Nickel	36.6	NV	490		×	--	×
Phosphorous	<100	NV			×	--	×
Potassium	4310	NV		Inherently Non-Toxic	×	--	×
Selenium	<1	54			×	--	×
Silver	1.27	1.5			×	--	×
Sodium	30500	NV	2300000		×	--	×
Strontium	88.3	NV	NV	Ca:Sr ratio greater than 1.0	×	--	×
Thallium	<0.1	0.8			×	--	×
Tin	<2	NV	NV		×	--	×
Titanium	10.8	100			×	--	×
Uranium	5.31	15			×	--	×
Vanadium	<2	NV	250		×	--	×
Zinc	274	10*	1100		×	--	×

Note:
1 – Guidance Document on Federal Interim Groundwater Quality Guidelines for Federal Contaminated Sites; Commercial Land-Use – Marine Life or Freshwater Life
2 – Ontario Ministry of the Environment Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Sites in Ontario. 2011. Commercial; Groundwater Components for Non-Potable Water Scenario, GW3 Pathway.
NV - No value provided in this source for this parameter
-- EPC not calculated as maximum site concentration is less than the applicable guideline
* - Based upon an interim value.
** - This is the concentration of the reanalyzed sampled. As previously noted, the presence of sediment was noted in the groundwater samples collected in March 2013. The monitoring wells with the two highest concentrations of mercury were resampled in May 2013. The monitoring well with the maximum of 1.3 µg/L in March was resampled with a concentration of 0.022 µg/L (May 2013). Therefore, the elevated mercury values present at this site (March 2013 samples) are assumed to be a result of sediment collected with the groundwater.
*** - See Section 5.1.1.2 for clarification
A- USEPA National Recommended Water Quality Criteria: 2002
B - World Health Organization 2004. Manganese and its compounds; Environmental Aspects. CICAD #63, Updated April 12, 2005.
Shaded and bold – carried forward for further assessment.

5.1.1.3 Summary of COPCs

The following COPCs were identified during the Hazard Identification and will be carried forward in the ERA:

- In soil;
  - Manganese;
  - Naphthalene; and
  - Phenanthrene.

The concentrations of naphthalene and phenanthrene in soil exceeded for the protection of freshwater life pathway only. The guideline is developed to be protective of aquatic life as a result of groundwater sweeping from the soil. As this soil has been impacted for greater than 50 years, the concentrations of PAHs in groundwater and soil are assumed to be at equilibrium. Given that groundwater concentrations were measured at the Site (measured naphthalene and phenanthrene in groundwater was less than the guideline for the protection of aquatic life), the modelled groundwater concentration from soil to groundwater was assumed to be overly conservative. In addition, the concentrations of naphthalene and phenanthrene in soil are less than the MOE soil to groundwater guideline (200 mg/kg – naphthalene and 270 mg/kg – phenanthrene). Therefore, the concentrations of naphthalene and phenanthrene in soil are considered to be within acceptable limits and were not carried forward for further assessment.

5.1.2 Ecological Receptor Identification

For the purpose of the ERA, it is neither practical nor necessary to individually assess each wildlife species that may potentially visit or occupy the Site. Instead, the potential adverse effects imposed on a carefully selected subset of wildlife receptors (VECs) exposed to petroleum hydrocarbon concentrations at the Site were evaluated. VECs were chosen for the ERA by focusing on wildlife species that were:

- Indigenous to the area and known to be on the Site;
- Most likely to receive the greatest exposure to contaminants due to their habitat, behavioural traits, and home range; and,
- Representative of various levels in the trophic web (*e.g.,* carnivore and herbivore).

The selection of ecological receptors was conducted such that each applicable habitat and trophic level at the Site was adequately represented. Moreover, each selected receptor was considered representative of other species occupying a similar position in the food web. In other words, results of the Risk Characterization stage for a selected ecological receptor can be used to make inferences about risk to other species occupying a similar niche in the food web. For example, if results of the ERA indicate that no unacceptable risk is expected for Masked Shrew then it can be expected that other insectivorous mammal species will be protected. Using these criteria, the ecological receptors assessed in the ERA were expected to provide adequate and conservative representation of the faunal and floral diversity at the Site.

The following species were identified as VECs and evaluated in the ERA:

- Masked Shrew (Sorex cinereus) – Insectivorous mammal
- Meadow Vole (Microtus pennsylvanicus) – Herbivorous mammal
- Herring Gull (Larus argentatus) - Omnivorous bird
- Terrestrial Invertebrate and Plants – Evaluated as a class
- Fish & Aquatic Invertebrates and Plants – Evaluated as a class

A brief profile for each of the species evaluated in this ERA is given below.

5.1.2.1 Masked Shrew

The masked shrew (*Sorex cinereus*) is the most widely distributed shrew in North America, and is found throughout most of Canada (Lee, 2001). It is common in moist environments and is found in open and closed forests, meadows, riverbanks, lakeshores, and willow thickets (Lee, 2001). Home range sizes are 0.2 ha to 0.6 ha (Saunders, 1988). Masked shrews, which weighs approximately 0.005 kg (U.S. EPA, 1993), are preyed upon by many small predators such as weasels, hawks, falcons, owls, domestic cats, foxes, snakes, and short-tailed shrews (Lee, 2001). The masked shrew does not hibernate (NWF, 2007) and feeds year-round on insects (dormant insects in winter) (NWF, 2007; Lee, 2001) including insect larvae, ants, beetles, crickets, grasshoppers, spiders, harvestmen, centipedes, slugs, and snails, but will also consume seeds and fungi (Lee, 2001). It consumes approximately 0.003 kg of wet-weight food per day and 0.001 L of water or its equivalent per day. The masked shrew's diet is modeled as including 2.5% terrestrial plant material and 97.5% terrestrial invertebrates. Based on its consumption of these foods, the masked shrew is estimated to incidentally ingest 4.44E-05 kg/day of dry soil.

5.1.2.2 Meadow Vole

The meadow vole (*Microtus pennsylvanicus*) is a small rodent (approximately 0.042 kg) which makes its burrows along surface runways in grasses or other herbaceous vegetation (U.S. EPA, 1993). It is active year-round and is the most widely distributed small grazing herbivore in North America, inhabiting moist to wet habitats including grassy fields, marshes, and bogs (U.S. EPA, 1993). Meadow voles are found throughout Canada, roughly to the limit of the tree line in the north. Home ranges vary considerably, from less than 0.0002 ha to greater than 0.083 ha (U.S. EPA, 1993). Meadow voles are a major prey item for predators such as hawks and foxes, and they feed primarily on vegetation such as grasses, leaves, sedges, seeds, roots, bark, fruits,

and fungi, but will occasionally feed on insects and animal matter (U.S. EPA, 1993, Neuburger, 1999). It consumes approximately 0.011 kg of wet-weight food per day and 0.006 L of water or its equivalent per day. The meadow vole's diet is modeled as including 98% terrestrial plant material and 2% terrestrial invertebrates. Based on its consumption of these foods, the meadow vole is estimated to incidentally ingest 3.15E-04 kg/day of dry soil.

5.1.2.3 Herring Gull

The Herring Gull (*Larus argentatus*) is a medium- to large-sized seabird, weighing approximately 1.1 kg (U.S. EPA 1993). It has the largest range of any North American gull (U.S. EPA 1993) and is one of the most widespread species in Canada (CWS & CWF 2010). Herring Gulls always nest near a body of water, and may be found beside lakes, rivers, in grassy meadows, on garbage dumps, golf courses, islands, cliffs, and islands (CWS & CWF 2010). In winter, Herring Gulls are most likely to congregate on beaches along oceans and other large bodies of water (CWS & CWF 2010). Herring Gulls feed on almost anything, including fish, squid, crustacea, molluscs, worms, insects, small mammals and birds, duck and gull eggs and chicks, amphibians, and garbage, with foraging home ranges from approximately 300 ha to 785,000 ha (U.S. EPA 1993). They will consume approximately 0.25 kg of wet weight food per day and 0.06 L of water or its equivalent per day.

The Herring Gull's diet is modeled here based on sea coast occupancy as including 7.5% soil invertebrates, 15% terrestrial mammals, 7.5% marine invertebrates, and 70% marine fish. Based on its consumption of these foods, the Herring Gull is estimated to incidentally ingest 3.62E-04 kg/day of dry soil, and 9.59E-04 kg/day of dry marine sediment.

5.1.2.4 Terrestrial Invertebrates and Plants

Soil invertebrates and terrestrial plants were assessed as a group rather than selecting a surrogate species as a representative. This reflects both the measure of exposure and the available toxicity data. The majority of dose –response data from plant and invertebrate toxicity tests relate observed effects to the contaminant concentration in the soil, and not a dose as common with birds and mammals. As a result, plant and soil invertebrate exposure is also based on the contaminant concentration in the soil. It does not rely on multi-pathway exposure modeling, and it is therefore not necessary to choose a surrogate species for which you would have exposure factors such as body weight, food ingestion rates, and diet composition. The simplified measure of exposure for plants and invertebrates is acceptable because they are assumed to always be in direct contact with soil and it is the single abiotic media from which they derive the majority of their exposure.

5.1.3 Exposure Pathway Identification

An exposure pathway describes the interaction between the COPC and the VEC. For terrestrial wildlife receptors (*i.e.,* birds and mammals), exposure to COPCs may occur through the following normal routes:

- Ingestion of soil and water (*i.e.,* as a result of feeding, drinking, and grooming); and,
- Ingestion of plants or prey species that have accumulated chemicals from the soil, and other media.

For plants and invertebrates exposure to COPCs may occur through the following normal route:

- Direct contact with soils.

However, as the Site is completely covered in asphalt and concrete, these normal exposure routes are not applicable. As stated in Section 1.1, the level of effect (*i.e.,* risk) depends on the receptor (*i.e.,* person or wildlife) being exposed, the route and duration of exposure (*e.g.,* oral exposure for chronic durations) and the hazard (*i.e.,* inherent toxicity) of the chemical. If all three components are present, the possibility of a toxicological risk exists. If one or more of these three components are missing, then there would be no unacceptable risk. As there is no known route of exposure for the ecological terrestrial receptors to be exposed to the elevated concentrations of COPC in soil and groundwater, no unacceptable risk is expected. Therefore, even with guideline exceedances, no further assessment is needed for the soil and groundwater located on the Site.

It should be noted if soil exposed areas are present once the proposed building is completed, ecological receptors may require further assessment at a later date. In addition, if soil is to be removed from the Site during construction, soil concentrations may require special disposal.

5.2 Discussion and Recommendations

The purpose of this ERA is to evaluate the potential that ecological receptors (*e.g.,* mammals, birds, plants, invertebrates) may experience toxicologically induced changes in ecological health as a result of exposure to COPCs found at the Site. As the Site is completely covered in asphalt and/or the proposed office building, no unacceptable risk to ecological receptors is expected because there is no probable exposure pathway for the ecological receptors to be exposed to the COPCs in the soil and groundwater.

6.0 MANAGEMENT LIMITS - PETROLEUM HYDROCARBONS

In addition to toxicological-based guidelines for human and ecological health, the CWS (2008) includes management limits to ensure protection of other potential effects as well as to incorporate consideration of additional scientific, technical and socio-economic factors. Factors currently considered in the management limits include free phase formation, exposure of workers in trenches to petroleum hydrocarbon vapours, fire and explosive hazards, effects on buried infrastructure, aesthetic considerations and technological factors. Below, each of the management limit effects have been considered as they apply to the Site and are summarized in Table 6.1.

- Formation of Free Phase - Free product was not observed at any sample location. As a result, the potential for substantive free product is considered to be low. However, due to the relatively high mobility and solubility of F1, CWS (2008) decided that the guideline for F1 fraction should be considered for the potential presence of free phase. Therefore, a F1 management limit of 700 mg/kg, in coarse soils was established. The PHC F1 faction concentration on site exceeds this management limit. Therefore, the potential for the formation of free product on site should be noted.
- Exposure of Workers in Trenches to Petroleum Hydrocarbon Vapours - Limits of 1,000 mg/kg for F1 and F2 Fractions are deemed protective of adverse effects on workers in trenches. PHC Fraction F1 and F2 concentrations that exceed this management limit have been observed on the Site. Therefore, in the event that trenching is to occur on Site in the future then an appropriate occupational health and safety plan should be developed and implemented if workers are to enter trenches.
- Effects on Buried Infrastructure - As stated in the CWS, the CCME did not derive a threshold for the PHC fraction for effects on buried infrastructure due to the inadequate data available. However, it is stated that potential effects of PHC on buried infrastructure should be addressed on a site-specific basis where utilities or other infrastructure are in contact with contaminated soils. As significant underground infrastructure is expected to be present on the Site once the building is completed, appropriate engineering controls/measures should be developed and implemented as part of the building design/construction.
- Fire and Explosive Hazards – It is unlikely that fire and explosive hazards are of great concern as the concentrations of soil vapours measured on the site are lower than the lower explosive limit for gasoline is 41,500 mg/m^3 (assuming an average molecular weight of 72 g/mol for the vapours (CCME 2008)). However, the CCME developed a PHC F1 and F2 fraction limit of 1,400 mg/kg and 5,200 mg/kg respectively to be further protection of this potential effect. As there are exceedances of the F2 fraction on site, underground enclosed spaces with very low air exchange rates that are in contact with or close to PHC contamination may require evaluation on a site-specific basis.
- Aesthetic Considerations - High concentrations of PHC can adversely affect aesthetics. Specific effects may include odours, visible impacts on soils, or effects on the taste of potable water. However, it is assumed that the CWS guidelines for the vapour intrusion pathway will be protective of odours in buildings in most cases. In addition as the site will be mainly covered and is a non-potable site, the visible impacts on soils or effects on the taste of potable water are essentially negligible. Therefore, the remaining petroleum hydrocarbon impacts on site are not considered to be an aesthetic concern.
- Technical Considerations – Based on the land use and the proposed building for the site, the upset limit for F3 in subsoil was determined to be 3,500 mg/kg. The PHC F3 upset limits were established in 2001 for consideration of toxic risk, aesthetics, effects on

infrastructure and bioremedial capabilities. However, due to lack of additional information in 2007, the CCME adopted this value in 2008 without review. There are exceedances of the PHC F3 guideline on this site. Therefore, appropriate engineering controls/measures should be considered as part of the building design/construction to address this potential effect.

Table 6.1 Management Limit Screening - Soil (PHC)

COPC	Maximum Concentration (mg/kg)	CCME CWS Management Limit (mg/kg)	Maximum > Management Limit
PHC F1 (C6-C10) - BTEX	1,400	700	✓
PHC F2 (C10-C16 Hydrocarbons)	24,000	1,700	✓
PHC F3 (C16-C34 Hydrocarbons)	14,300	3,500	✓

As discussed above, PHC F1, F2, and F3 fraction concentrations on site are greater than the Management Limit Values. Therefore, during the design and construction of the building and associated services, consideration should be given to the concentrations of PHC F1, F2, and F3 on Site.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Stantec Consulting Ltd. (Stantec) was retained by Public Works and Government Services Canada (PWGSC) on behalf of Fisheries and Oceans Canada/Canadian Coast Guard to conduct a human health and ecological risk assessment (HHERA) at the Canadian Coast Guard (CCG) Southside Base, Berth 28 (the Site) located off Southside Road in St. John's, Newfoundland and Labrador (NL). The purpose of this HHERA is to determine whether chemical concentrations identified at the Site pose unacceptable risk to human (*e.g.,* Site Workers and Visitors) or ecological (*e.g.,* birds, mammals, plants) receptors given the current and future land use.

The conclusions of the study may be summarized as follows:

7.1 Human Health Risk Assessment

In the HHRA, benzene and PHC fractions (F1 and F2) in soil were carried forward for exposure to indoor air for the Site Worker and Site Visitor; while carcinogenic PAHs and lead in soil were carried forward for direct contact for the Construction worker. The SSTLs calculated for the Site Worker (building occupant) and Site Visitor were greater than the maximum concentration on site with the exception of the PHC fractions (F1 and F2). In addition, soil vapour data was collected as part of the HHRA to further evaluate the potential for vapour intrusion into the proposed site building, and to provide a more realistic estimate of anticipated indoor air concentrations of the COPCs in the proposed site building as a result of subsurface petroleum hydrocarbon impacted soil present on the property. The results of the soil vapour sampling program supported the HHRA findings, and show that unacceptable risk may be present at the site for a Site Worker and Site Visitor (*i.e.,* building occupant) exposed to F1 and F2 PHC fractions and benzene via inhalation of indoor air with the concentrations in soil vapour sample VP04 having predicted HQ/ILCRs greater than the target HQ/ILCR. Therefore, remediation or risk management measures should be developed to limit the exposure of the Site Worker and Site Visitor to within acceptable limits. Using the soil data, the SSTLs were calculated for benzene (SSTL = 2.35 mg/kg), PHC F1 (SSTL = 474 mg/kg) and F2(SSTL = 4,560 mg/kg).

The Construction Worker will be exposed to soil as it is assumed that there will be earthwork activity during the construction of the proposed office building. As a result, the construction worker will be exposed to the lead and PAHs concentrations in the soil. However, the SSTLs calculated for the Construction Worker were greater than the EPCs for lead and PAHs. Therefore, the concentrations of lead and PAHs in the soil should not result in unacceptable risk. The indoor air pathway is not of concern for the Construction Worker, and as a result the concentrations of benzene and PHC fractions are not considered a concern. In conclusion, no unacceptable risk to the Construction Worker is expected on Site as a result of chemicals in soil.

All chemical concentrations (PHCs, PAHs, PCBs, and inorganic parameters analysed) in groundwater were within acceptable limits for human health and no unacceptable risk is expected as a result of exposure to groundwater on the Site.

7.2 Ecological Risk Assessment

No unacceptable risk to ecological receptors is expected as no COPCs in groundwater were identified and surface cover prevents exposure to underlying soil at the site.

7.3 Management Limits – Petroleum Hydrocarbons

PHC F1, F2, and F3 fraction concentrations on site are greater than the Management Limit Values. Therefore, during the design and construction of the building and associated services, consideration should be given to the concentrations of PHC F1, F2, and F3 in soil on Site.

7.4 General

Based on the findings of the HHRA, there are potential unacceptable risks for the Site Worker and Site Visitor on Site as a result of benzene, F1 and F2 PHC fractions in the soil. An area of approximately 340 m^2 of soil on the site in the vicinity of boreholes BH3 and BH6 is impacted with F1 and F2 PHC fraction concentrations exceeding the toxicological based SSTLs (benzene =2.35 mg/kg; F1 = 474 mg/kg; F2 = 4560 mg/kg) for indoor air. The impacted area is shown on Drawing No. 121412715-EE-02 in Appendix A, and is defined based on field and analytical evidence identified in boreholes BH3 and BH6 during Stantec Phase II ESA (Stantec, 2013a), as well as analytical results from historical test pits TP106 and TP107 completed by MGI in 2001, as summarized in Stantec's Phase II ESA (2013a). Soil samples with concentrations of petroleum hydrocarbons that exceed the SSTLs in this area were identified at depths ranging from 1.3 m to 3.8 mbgs. Based on the defined area of impacts and identified thickness of impacts (*i.e.,* approximately 2.5 m), the approximate volume of petroleum hydrocarbon impacted soil exceeding SSTLs in this area is 850 m^3.

It should be noted that the F1 and F2 PHC fraction concentrations in BH15 also exceed the toxicological based SSTLs (benzene =2.35 mg/kg; F1 = 474 mg/kg; F2 = 4,560 mg/kg) for indoor air. However, this sampling location is greater than 30 m from the proposed building footprint and is assumed to be covered by an asphalt parking lot. Therefore, the indoor air pathway (vapour intrusion exposure pathway) is not applicable for this sampling location. However, it should be noted that if a building is proposed in the BH15 location, PHC concentrations may need further consideration for the indoor air pathway in this area.

Based on the information provided above, remediation or risk management measures should be developed to limit the exposure of the Site Worker and Site Visitor to within acceptable limits. It should be noted that these recommendations have been addressed in a remedial action plan developed as part of this project under a separate cover.

8.0 Closure

This report has been prepared for the sole benefit of Public Works and Government Services Canada (PWGSC), on behalf of Fisheries and Oceans Canada/Canadian Coast Guard. The report may not be used by any other person or entity without the express written consent of Stantec Consulting Ltd. and PWGSC.

Any uses that a third party makes of this report, or any reliance on decisions to be made based on it, are the responsibility of such third parties. Stantec accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices current at the time the work was performed. Conclusions and recommendations presented in this report should not be construed as legal advice.

The conclusions presented in this report represent the best technical judgment of Stantec based on the data obtained from the work. The conclusions are based on the Site conditions observed by Stantec at the time the work was performed at the specific testing and/or sampling locations, and can only be extrapolated to an undefined limited area around these locations. The extent of the limited area depends on the soil and surface water conditions, as well as the history of the Site reflecting natural, construction and other activities. In addition, analyses have been carried out for a limited number of chemical parameters, and it should not be inferred that other chemical species are not present. Due to the nature of the investigation and the limited data available, Stantec cannot warrant against undiscovered environmental liabilities.

This risk assessment was undertaken exclusively for the purpose outlined herein and was limited to those contaminants, exposure pathways, receptors, and related uncertainties specifically referenced in this report. This work was specific to the Site conditions and land use considerations described herein. The report cannot be used or applied under any circumstances to another location or situation or for any other purpose without further evaluation of the data and related limitations.

This document describes only the applicable risks associated with the identified environmental hazards, and is not intended to imply a risk-free site. If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein.

Respectfully submitted,

STANTEC CONSULTING LTD.

For

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PROVINCE OF NEWFOUNDLAND AND LABRADOR
PEG Newfoundland and Labrador
PERMIT HOLDER
This Permit Allows
STANTEC CONSULTING LTD.
To practice Professional Geoscience in Newfoundland and Labrador.
Permit No. as issued by PEG J0291
which is valid for the year 2014

REGISTERED PROFESSIONAL GEOSCIENTIST
CAROLYN ANSTEY-MOORE
SIGNATURE
03/31/14
DATE
NEWFOUNDLAND & LABRADOR

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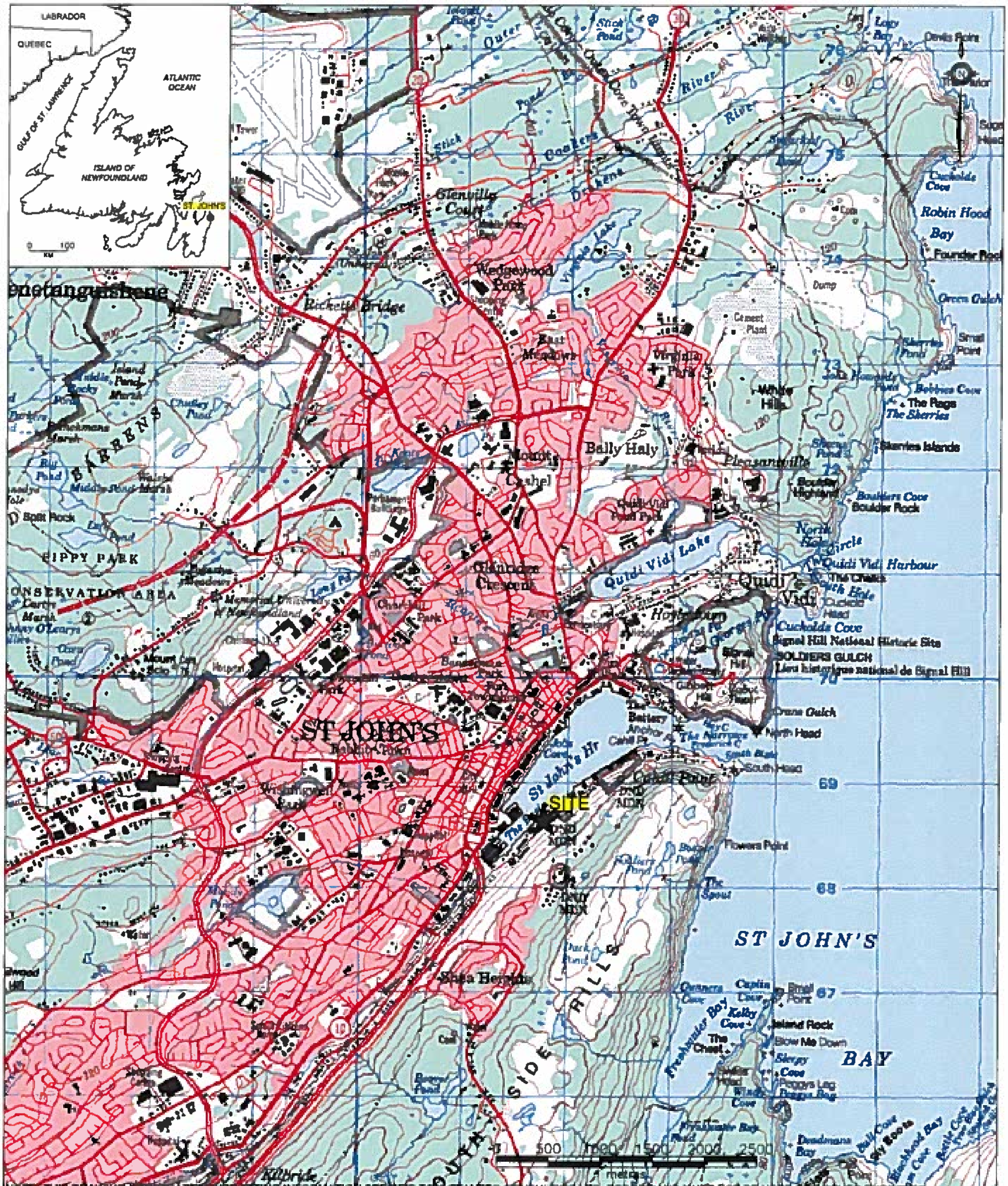
APPENDIX A

Drawings



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	DRAWN BY: N.M.	CHECKED BY:
PROJECT TITLE: HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT, CANADIAN COAST GUARD SOUTHSIDE BASE, BERTH 28 SOUTHSIDE ROAD, ST. JOHN'S, NL	EDITED BY: -	REV. No. 0
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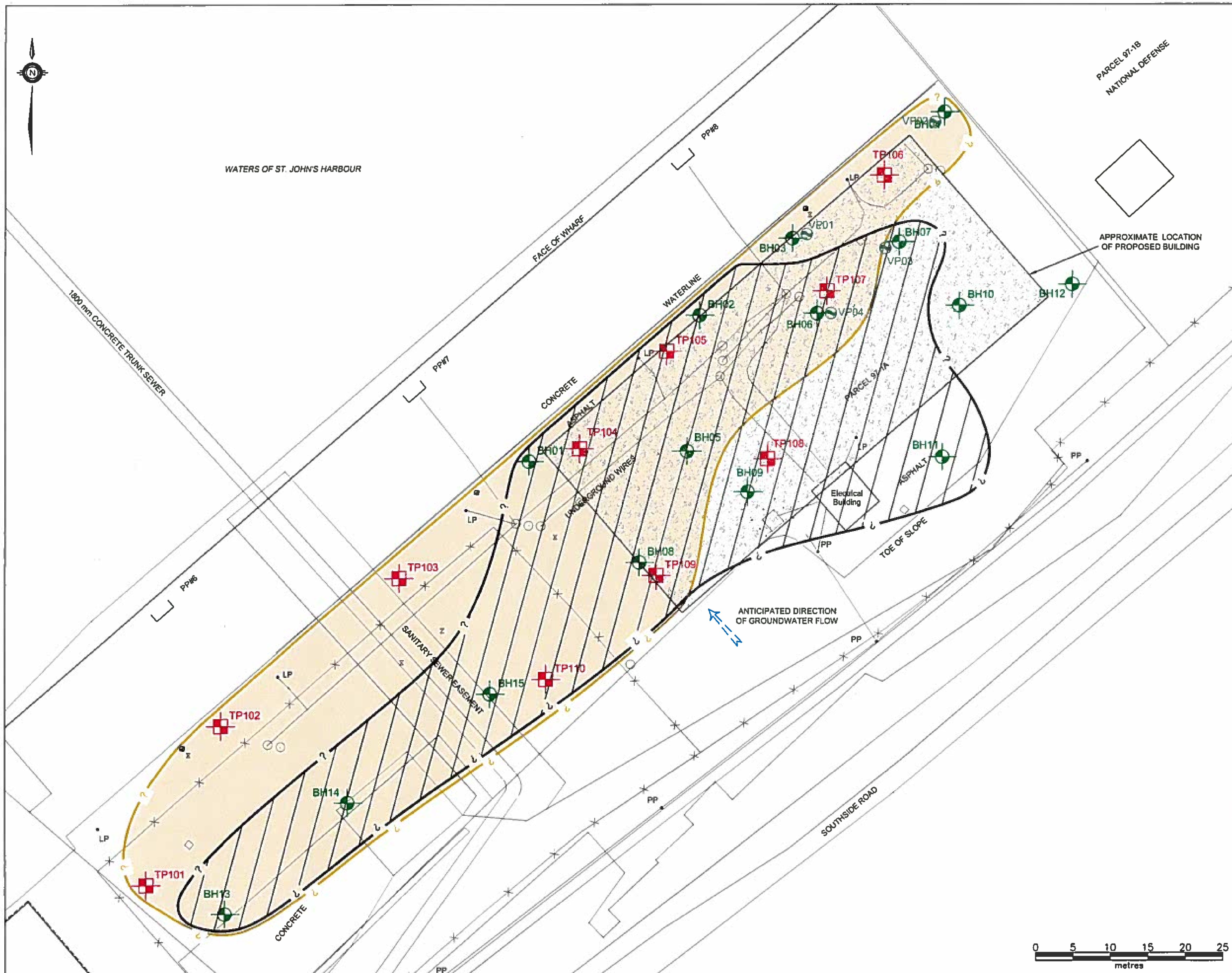

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LEGEND

- STANTEC BOREHOLE/MONITOR WELL LOCATION (2013)
- MGI TEST PIT LOCATION (2001)
- AREA OF SOIL WITH PHC, METALS AND/OR PAH CONCENTRATIONS EXCEEDING APPLICABLE GUIDELINES FOR A COMMERCIAL SITE (PHASE II ESA)
- AREA OF GROUNDWATER WITH PHC,METALS AND/OR PAH CONCENTRATIONS EXCEEDING APPLICABLE GUIDELINES FOR A COMMERCIAL SITE (PHASE II ESA)
- SOIL VAPOUR PROBE LOCATION (2013) (INSTALLED TO 1.5 mbgs AND SCREENED FROM 1.0 - 1.5 mbgs, 1" Ø PROBES)

NOTES:

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SERVICES CANADA

PROJECT TITLE:

HUMAN HEALTH AND ECOLOGICAL RISK
ASSESSMENT, CANADIAN COAST GUARD
SOUTHSIDE BASE, BERTH 28
SOUTHSIDE ROAD, ST. JOHN'S, NL

DRAWING TITLE:

SITE PLAN

Stantec Consulting Ltd.

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DRAWING No: 121412715-EE-02	CAD FILE: 121412715-EE-02.dwg	

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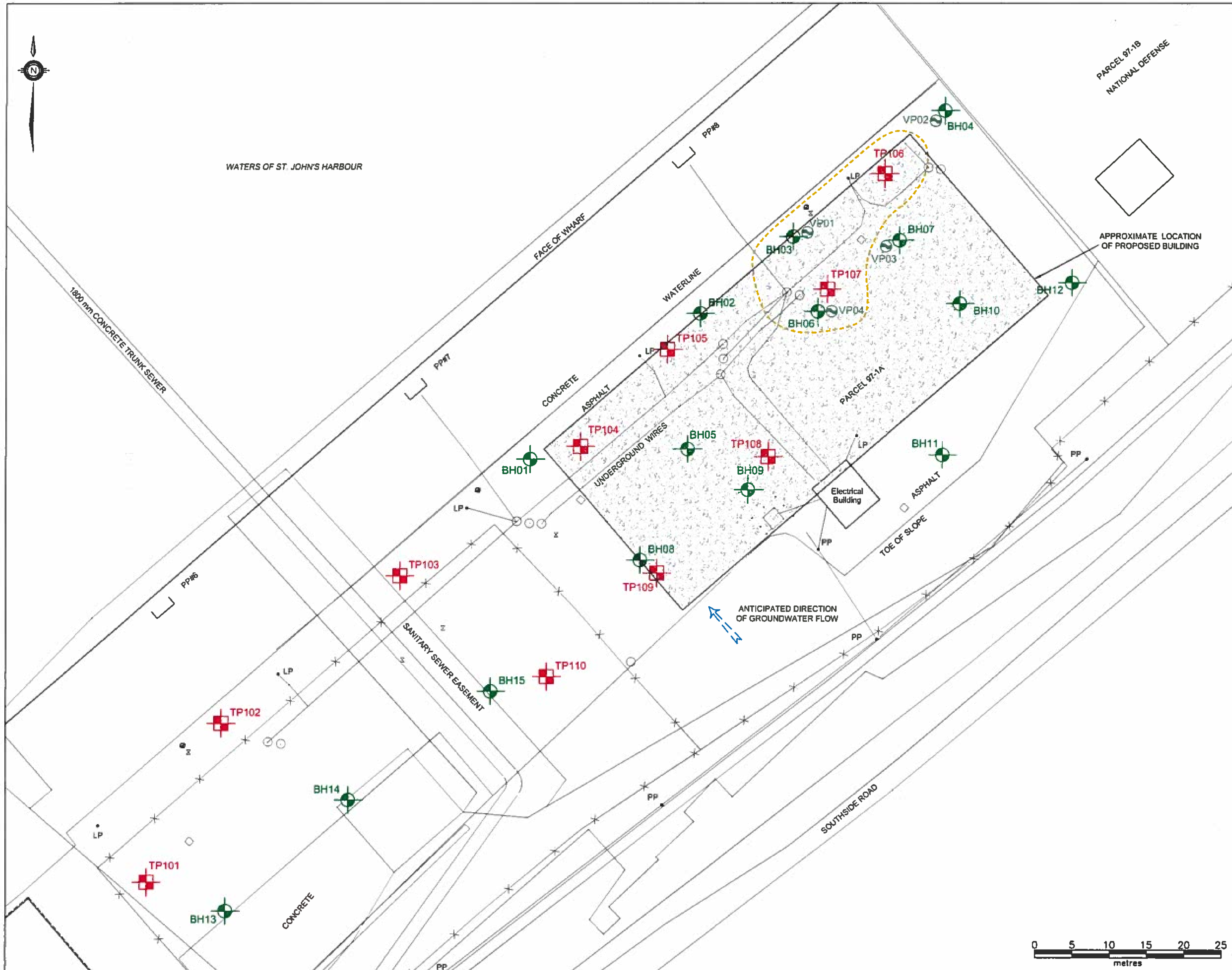

LEGEND

- STANTEC BOREHOLE/MONITOR WELL LOCATION (2013)
- MGI TEST PIT LOCATION (2001)
- AREA OF SOIL WITH CONCENTRATIONS OF BENZENE AND PHC FRACTIONS F1 & F2 > SSTLs
- SOIL VAPOUR PROBE LOCATION (2013) (INSTALLED TO 1.5 mbgs AND SCREENED FROM 1.0 - 1.5 mbgs, 1" Ø PROBES)

NOTES:

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PROJECT TITLE:

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ASSESSMENT, CANADIAN COAST GUARD
SOUTHSIDE BASE, BERTH 28
SOUTHSIDE ROAD, ST. JOHN'S, NL

DRAWING TITLE:

ESTIMATED EXTENT OF PETROLEUM
HYDROCARBON IMPACTS IN SOIL
GREATER THAN SSTL

Stantec Consulting Ltd.

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APPENDIX B

Data from Phase II ESA

Stantec Report 121412551

Table B.1 Results of Laboratory Analysis of Petroleum Hydrocarbons in Soil
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Sample ID	Depth (mbgs)	Date	Benzene	Toluene	Ethylbenzene	Xylenes	C_6-C_{10} F1	C_{10}-C_{16} F2	C_{16}-C_{32}[5] F3	>C_{32}[5] F4	Modified TPH - Tier I[4]	Comments
		RDL	0.025	0.025	0.025	0.05	2.5	10	15	-	15	-
		Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	-	mg/kg	-
		CWS [1, 2]	0.03	0.37	0.082	11	320 (eco/ indoor) 970 (gw)	260 (eco) 380 (gw)	1,700 (eco)	3,300	-	-
		CWS Management Limit [3]	-	-	-	-	700	1,000	3,500	10,000	-	-
BH1-SS3	1.6 - 2.2	04-Mar-13	**0.16**	0.28	0.052	0.40	17	220	450	-	700*	WFO/LO
BH1-SS9	5.7 - 6.3	04-Mar-13	nd	nd	nd	nd	nd	nd	157	-	150*	NR
BH2-SS5	2.9 - 3.6	27-Feb-13	nd	nd	nd	nd	nd	***1,800***	730	-	2,500	WFO
BH2-SS7	4.4 - 5.0	27-Feb-13	**0.83**	0.29	**0.66**	1.2	190	nd	43	-	230*	NR
BH3-SS4	2.6 - 3.2	06-Mar-13	**0.36**	0.15	**1.8**	3.4	***1,400***	***24,000***	**14,300**	-	40,000	WFO
BH4-SS5	2.2 - 2.6	28-Feb-13	**0.18**	0.18	nd	0.31	10	***1,300***	1070	-	2,400	WFO
BH5-SS4	2.1 - 2.7	21-Feb-13	nd	0.22	0.045	0.076	5.4	36	230	-	270	NR
BH6-SS4	2.9 - 3.5	25-Feb-13	nd	0.14	**0.73**	4.0	***1,200***	***4,300***	**2,170**	-	7,700	WFO
BH7-SS1	0.2 - 0.7	25-Feb-13	nd	nd	nd	nd	nd	nd	32	-	32*	PLO
BH7-SS6	3.4 - 4.0	25-Feb-13	nd	nd	nd	nd	nd	nd	24	-	24*	NR
BH8-SS4	2.1 - 2.7	20-Feb-13	nd	nd	nd	nd	18	80	21	-	120	WFO
BH9-SS2	0.8 - 1.4	24-Feb-13	nd	nd	nd	nd	nd	nd	nd	-	nd	-
BH10-SS1	0.4 - 1.2	05-Mar-13	0.030	0.056	nd	0.079	7.1	66	135	-	210	WFO / NR-LO
BH11-SS1	0.3 - 0.8	07-Mar-13	nd	nd	nd	nd	nd	nd	31	-	31*	LO
BH12-SS2	1.0 - 1.3	03-Mar-13	nd	nd	nd	nd	nd	nd	137	-	140	NR
BH13-SS5	2.1 - 3.2	22-Feb-13	**0.038**	0.079	nd	0.057	3.5	180	138	-	320	WFO
BS14-SS3	1.6 - 2.2	24-Feb-13	**0.033**	0.10	0.044	0.34	nd	***670***	1480	-	2,100	NR
BS14-AS3C	2.3	24-Feb-13	nd	nd	nd	nd	nd	19	**2,510**	-	2,500*	LO
BH15-SS1	0.2 - 0.8	26-Feb-13	nd	nd	nd	nd	nd	nd	16	-	16*	PLO
BH15-SS1 Lab-Dup	-	-	-	-	-	-	-	nd	19	-	-*	-
BH15-SS3	1.6 - 2.2	26-Feb-13	nd	nd	**0.085**	0.42	**720**	***5,000***	**1,750**	-	7,500	WFO

Notes:
1 = CCME CSQG = Canadian Council of Ministers of the Environment (CCME) Canadian Soil Quality Guidelines (CSQGs) for the Protection of Environmental and Human Health for BTEX (CSQG on-line 2013) - Commercial Site, coarse-grained soil
2 = CCME CWS PHC = CCME Canada Wide Standards (CWS) for Petroleum Hydrocarbons (PHC) in Soil (January 2008) - Commercial Site (eco soil contact, vapour inhalation (indoor) and protection of groundwater for aquatic life) (Table 3)
3 = CCME CWS PHC Management Limit for a Commercial Site (January 2008)
4 = Modified TPH = total petroleum hydrocarbons excluding BTEX
5 = Atlantic PIRI analytical method does not analyse for >C32. Laboratory certificate indicates (Yes or No) whether chromatogram for each sample returns to baseline after C32. Samples are considered to have returned to baseline if the area from C32-C36 is less than 10% of the area from C10-C32.
* = Baseline not reached at C32; sample may contain carbon fractions >C32
Triple silica gel clean-up was used by the laboratory to remove organic interferences from sample extracts.
RDL = Reportable Detection Limit for routine analysis; nd = Not detected above standard RDL; na = Not applicable
FO = Fuel Oil; WFO = weathered fuel oil; LO = Lube Oil; PLO = Possible Lube Oil; NR = no resemblance to petroleum hydrocarbons
mbgs = metres below ground surface
Bold/Shaded = Value exceeds CCME and/or CWS eco/indoor guideline
Italics = Value exceeds CWS gw guideline
Underlined = Value exceeds CWS Management Limit

Table B.2 Results of Laboratory Analysis of Fractionated Petroleum Hydrocarbons in Soil
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameters	RDL	Units	CWS [1, 2]	CWS Mgmt. Limit [3]	BH6-SS4	BH15-SS3	BH15-SS3 Lab-Dup
					2.9 - 3.5 mbgs	1.6 - 2.2 mbgs	-
					25-Feb-13	26-Feb-13	-
Benzene	0.025	mg/kg	0.03	-	**0.0870**	nd	-
Toluene	0.025	mg/kg	0.37	-	0.2	nd	-
Ethylbenzene	0.025	mg/kg	0.082	-	**0.60**	**0.10**	-
Xylenes	0.050	mg/kg	11	-	3.6	0.41	-
Aliphatic >C6-C8	2.0	mg/kg	-	-	390	160	-
Aliphatic >C8-C10	4.0	mg/kg	-	-	750	570	-
>C8-C10 Aromatics (-EX)	0.10	mg/kg	-	-	80	44	-
Aliphatic >C10-C12	8.0	mg/kg	-	-	880	1,000	780
Aliphatic >C12-C16	15	mg/kg	-	-	2,100	2,100	1,600
Aliphatic >C16-C21	15	mg/kg	-	-	1,200	790	590
Aliphatic >C21-<C32	15	mg/kg	-	-	260	96	68
Aromatic >C10-C12	4.0	mg/kg	-	-	340	220	240
Aromatic >C12-C16	15	mg/kg	-	-	620	580	570
Aromatic >C16-C21	15	mg/kg	-	-	570	370	330
Aromatic >C21-<C32	15	mg/kg	-	-	180	98	81
C_6-C_{10} - F1	-	mg/kg	320 (eco/indoor) 970 (gw)	700	***<u>1,220</u>***	**774**	-
C_{10}-C_{16} - F2	-	mg/kg	260 (eco) 380 (gw)	1,000	***<u>3,940</u>***	***<u>3,900</u>***	-
C_{16}-C_{32}[5] - F3	-	mg/kg	1,700 (eco)	3,500	**2,210**	1,354	-
>C_{32}[5] - F4	-	-	3,300 (eco)	10,000	-	-	-
Modified TPH - Tier 2 [4]	15	mg/kg	-	-	7,300	6,000	-
Resemblance	-	-	-	-	WFO, LO	WFO, PLO	-

Notes:

1 = CCME CSQG = Canadian Council of Ministers of the Environment (CCME) Canadian Soil Quality Guidelines (CSQGs) for the Protection of Environmental and Human Health for BTEX (CSQG on-line September 2012) - Commercial Site, coarse-grained soil

2 = CCME CWS PHC = CCME Canada Wide Standards (CWS) for Petroleum Hydrocarbons (PHC) in Soil (January 2008) - Commercial Site (eco soil contact, vapour inhalation (indoor) and protection of groundwater for aquatic life) (Table 3)

3 = CCME CWS PHC Management Limit for a Commercial Site (January 2008)

4 = Modified TPH = total petroleum hydrocarbons excluding BTEX

5 = Atlantic PIRI analytical method does not analyse for >C32. Laboratory certificate indicates (Yes or No) whether chromatogram for each sample returns to baseline after C32. Samples are considered to have returned to baseline if the area from C32-C36 is less than 10% of the area from C10-C32.

Triple silica gel clean-up was used by the laboratory to remove organic interferences from sample extracts.

RDL = Reportable Detection Limit for routine analysis; nd = Not detected above standard RDL; na = Not applicable

WFO = weathered fuel oil; LO = Lube Oil; PLO = Possible Lube Oil

mbgs = metres below ground surface

Bold/Shaded = Value exceeds CCME and/or CWS eco/indoor guideline

Italics = Value exceeds CWS gw guideline

<u>Underlined = Value exceeds CWS Management Limit</u>

Table B.3 Results of Laboratory Analysis of Available Metals in Soil
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameters	RDL	Units	Guideline[1]	BH1-SS3	BH1-SS9	BH2-SS5	BH2-SS5 Lab-Dup	BH2-SS5 Lab-Dup 2	BH2-SS7	BH3-SS4	BH4-SS5	BH5-SS4
				1.6 - 2.2 mbgs	5.7 - 6.3 mbgs	2.9 - 3.6 mbgs	-	-	4.4 - 5.0 mbgs	2.6 - 3.2 mbgs	2.2 - 2.6 mbgs	2.1 - 2.7 mbgs
				04-Mar-13	04-Mar-13	27-Feb-13	-	-	27-Feb-13	06-Mar-13	28-Feb-13	21-Feb-13
Aluminum	10	mg/kg	-	11,000	12,000	15,000	14,000	-	6,100	11,000	11,000	16,000
Antimony	2.0	mg/kg	40	4	nd	nd	nd	-	nd	nd	4.5	nd
Arsenic	2.0	mg/kg	12	11	5	**19**	**20**	-	**16**	9.6	**46**	6.8
Barium	5.0	mg/kg	2,000	58	30	54	52	-	52	63	120	41
Beryllium	2.0	mg/kg	8	nd	nd	nd	nd	-	nd	nd	nd	nd
Boron	5.0	mg/kg	-	nd	61	nd	nd	-	nd	nd	nd	nd
Cadmium	0.30	mg/kg	22	0.35	1	nd	nd	-	nd	1	0.88	0.9
Chromium	2.0	mg/kg	87	17	17	28	38	-	15	32	51	22
Cobalt	1.0	mg/kg	300	9.4	6	12	13	-	5.4	11	15	8.5
Copper	2.0	mg/kg	91	38	26	57	**120**	59	23	**280**	**130**	24
Iron	50	mg/kg	-	31,000	21,000	60,000	64,000	-	27,000	170,000	57,000	32,000
Lead	0.50	mg/kg	260	220	18	230	230	-	**280**	**390**	**2,700**	170
Manganese	2.0	mg/kg	-	690	350	760	790	-	370	1,100	360	620
Mercury	0.10	mg/kg	24	0.3	nd	0.22	0.29	-	0.17	0.36	0.72	nd
Molybdenum	2.0	mg/kg	40	3.1	15	7.6	10	-	7.8	18	11	2.2
Nickel	2.0	mg/kg	50	15	15	26	29	-	20	25	**73**	19
Selenium	2.0	mg/kg	2.9	nd	1.4	nd	nd	-	1.2	nd	2.0	nd
Silver	0.50	mg/kg	40	nd	2.1	0.9	0.77	-	0.76	1.6	nd	nd
Strontium	5.0	mg/kg	-	25	780	31	37	-	23	84	63	11
Thallium	0.10	mg/kg	1	nd	0.28	0.15	0.14	-	0.24	nd	0.37	nd
Tin	2.0	mg/kg	300	12	nd	5.7	6.3	-	3.4	18	**320**	3.9
Uranium	0.10	mg/kg	33	0.84	10	3.1	3.4	-	1.9	3.6	3.5	0.62
Vanadium	2.0	mg/kg	130	20	30	28	28	-	15	36	45	23
Zinc	5.0	mg/kg	360	120	100	120	130	-	62	200	**880**	88

Notes:
1 = Canadian Council of Ministers of the Environment (CCME) Canadian Soil Quality Guidelines (CSQG on-line 2013). Commercial land use.

RDL = Reportable Detection Limit for routine analysis
nd = Not detected above standard RDL
mbgs = metres below ground surface
Lab-Dup = Laboratory QA/QC duplicate sample
Bold/Shaded = Value exceeds applicable guideline

Table B.3 Results of Laboratory Analysis of Available Metals in Soil (cont.)
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameters	RDL	Units	Guideline[1]	BH6-SS4	BH6-SS4 Lab-Dup	BH7-SS1	BH7-SS6	BH8-SS4	BH9-SS2	BH10-SS1	BH11-SS1
				2.9 - 3.5 mbgs	-	0.2 - 0.7 mbgs	3.4 - 4.0 mbgs	2.1 - 2.7 mbgs	0.8 - 1.4 mbgs	0.4 - 1.2 mbgs	0.3 - 0.8 mbgs
				25-Feb-13	-	25-Feb-13	25-Feb-13	20-Feb-13	24-Feb-13	05-Mar-13	07-Mar-13
Aluminum	10	mg/kg	-	13,000	13,000	7,600	16,000	16,000	11,000	11,000	10,000
Antimony	2.0	mg/kg	40	3.6	nd	nd	nd	nd	nd	nd	nd
Arsenic	2.0	mg/kg	12	7.9	8.0	3.5	3.6	2.9	4.7	4.6	4.8
Barium	5.0	mg/kg	2,000	59	52	36	38	20	34	41	36
Beryllium	2.0	mg/kg	8	nd	nd	nd	nd	nd	nd	nd	nd
Boron	5.0	mg/kg	-	nd	nd	nd	nd	nd	nd	nd	nd
Cadmium	0.30	mg/kg	22	nd	nd	0.46	nd	nd	nd	nd	0.32
Chromium	2.0	mg/kg	87	21	17	12	21	35	9.4	14	21
Cobalt	1.0	mg/kg	300	11	11	6.1	8.8	8.2	8.3	7.9	7.8
Copper	2.0	mg/kg	91	31	30	11	45	20	14	21	25
Iron	50	mg/kg	-	27,000	26,000	17,000	29,000	33,000	20,000	23,000	26,000
Lead	0.50	mg/kg	260	210	200	12	15	42	12	32	12
Manganese	2.0	mg/kg	-	690	680	660	620	630	880	840	820
Mercury	0.10	mg/kg	24	0.11	nd	nd	nd	nd	nd	nd	nd
Molybdenum	2.0	mg/kg	40	3.2	3.3	nd	nd	3.9	nd	nd	nd
Nickel	2.0	mg/kg	50	13	13	7.2	21	21	6.8	12	18
Selenium	2.0	mg/kg	2.9	nd	nd	nd	nd	nd	nd	nd	nd
Silver	0.50	mg/kg	40	0.75	nd	nd	5.3	nd	nd	nd	nd
Strontium	5.0	mg/kg	-	21	20	6.3	21	7.6	19	18	30
Thallium	0.10	mg/kg	1	nd	nd	nd	nd	nd	nd	nd	nd
Tin	2.0	mg/kg	300	4.1	2.5	nd	nd	nd	nd	nd	nd
Uranium	0.10	mg/kg	33	1.4	1.4	0.38	3.7	0.48	0.63	0.42	0.64
Vanadium	2.0	mg/kg	130	19	20	8.9	25	22	13	19	26
Zinc	5.0	mg/kg	360	130	120	45	63	69	54	81	59

Notes:
1 = Canadian Council of Ministers of the Environment (CCME) Canadian Soil Quality Guidelines (CSQG on-line 2013). Commercial land use.

RDL = Reportable Detection Limit for routine analysis
nd = Not detected above standard RDL
mbgs = metres below ground surface
Lab-Dup = Laboratory QA/QC duplicate sample

Table B.3 Results of Laboratory Analysis of Available Metals in Soil (cont.)
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameters	RDL	Units	Guideline[1]	BH12-SS2	BH13-SS3	BH13-SS5	BH14-SS3	BH14-AS3C	BH15-SS1	BH15-SS3
				1.0 - 1.3 mbgs	1.3 - 1.9 mbgs	2.1 - 3.2 mbgs	1.6 - 2.2 mbgs	2.3 mbgs	0.2 - 0.8 mbgs	1.6 - 2.2 mbgs
				03-Mar-13	22-Feb-13	22-Feb-13	24-Feb-13	24-Feb-13	26-Feb-13	26-Feb-13
Aluminum	10	mg/kg	-	9,200	14,000	13,000	9,700	6,800	7,800	17,000
Antimony	2.0	mg/kg	40	nd	nd	nd	nd	nd	nd	nd
Arsenic	2.0	mg/kg	12	4.8	5.3	8.7	**15**	2.9	4.2	12
Barium	5.0	mg/kg	2,000	45	33	72	140	26	21	110
Beryllium	2.0	mg/kg	8	nd	nd	nd	nd	nd	nd	nd
Boron	5.0	mg/kg	-	nd	nd	nd	nd	nd	nd	nd
Cadmium	0.30	mg/kg	22	nd	nd	nd	0.31	nd	nd	nd
Chromium	2.0	mg/kg	87	13	24	24	33	33	7.1	18
Cobalt	1.0	mg/kg	300	7.8	11	9.9	8.7	5.1	6.5	10
Copper	2.0	mg/kg	91	23	24	36	51	15	12	43
Iron	50	mg/kg	-	25,000	29,000	31,000	34,000	16,000	18,000	34,000
Lead	0.50	mg/kg	260	26	27	160	**340**	11	14	**850**
Manganese	2.0	mg/kg	-	790	850	800	610	540	730	620
Mercury	0.10	mg/kg	24	nd	nd	0.22	0.65	nd	nd	0.44
Molybdenum	2.0	mg/kg	40	nd	nd	2.8	5	nd	nd	nd
Nickel	2.0	mg/kg	50	12	16	15	18	9.6	6.7	20
Selenium	2.0	mg/kg	2.9	nd	nd	nd	nd	nd	nd	nd
Silver	0.50	mg/kg	40	nd	nd	nd	0.77	nd	nd	nd
Strontium	5.0	mg/kg	-	15	24	31	33	9.7	6.3	30
Thallium	0.10	mg/kg	1	nd	nd	nd	0.11	nd	nd	0.11
Tin	2.0	mg/kg	300	3.8	nd	4.2	15	nd	nd	27
Uranium	0.10	mg/kg	33	0.49	0.56	0.66	0.66	0.38	0.35	0.86
Vanadium	2.0	mg/kg	130	16	26	21	24	30	9.3	23
Zinc	5.0	mg/kg	360	82	78	110	140	53	47	140

Notes:
1 = Canadian Council of Ministers of the Environment (CCME) Canadian Soil Quality Guidelines (CSQG on-line 2013). Commercial land use.

RDL = Reportable Detection Limit for routine analysis
nd = Not detected above standard RDL
mbgs = metres below ground surface
Bold/Shaded = Value exceeds applicable guideline

Table B.4 Results of Laboratory Analysis of Polycyclic Aromatic Hydrocarbons in Soil
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameter	RDL	Units	B(a)P PEF	CCME $CSQG_{HH}$[1] (All Land Uses)	HH Guidelines - Other Jurisdictions[2] (All Land Uses)	CCME $CSQG_{EH}$[1] - (Comm.)	BH1-SS3	BH1-SS3 Lab-Dup	BH1-SS9	BH2-SS5	BH2-SS7	BH3-SS4	BH4-SS5
							1.6 - 2.2 mbgs	-	5.7 - 6.3 mbgs	2.9 - 3.6 mbgs	4.4 - 5.0 mbgs	2.6 - 3.2 mbgs	2.2 - 2.6 mbgs
							04-Mar-13	-	04-Mar-13	27-Feb-13	27-Feb-13	06-Mar-13	28-Feb-13
Non-Carcinognic PAHs													
1-Methylnaphthalene	0.01	mg/kg	-	-	560*	-	0.37	0.26	nd	0.69	0.058	12	0.96
2-Methylnaphthalene	0.01	mg/kg	-	-	560*	-	0.44	0.32	nd	nd	0.031	2.9	0.96
Acenaphthene	0.01	mg/kg	-	-	96*	-	0.067	0.053	nd	nd	0.16	4.3	1.2
Acenaphthylene	0.01	mg/kg	-	-	9.6*	-	nd	nd	nd	nd	0.088	nd	1.7
Anthracene	0.01	mg/kg	-	-	4,200*	32	0.20	0.20	nd	1.5	0.4	nd	2.2
Fluoranthene	0.01	mg/kg	-	-	9.6*	180	1.4	1.8	0.05	3.4	1.6	5.5	17
Fluorene	0.01	mg/kg	-	-	5,600*	-	0.13	0.097	nd	0.55	0.14	3.6	nd
Naphthalene	0.01	mg/kg	-	-	2,800*	22/0.013[4]	0.33	0.22	nd	0.48	0.055	2.9	1.5
Perylene	0.01	mg/kg	-	-	2,800**	-	0.18	0.19	0.44	0.17	0.12	0.32	1.3
Phenanthrene	0.01	mg/kg	-	-	3,800**	50/0.046[4]	0.73	0.73	nd	1.1	0.64	11	13
Pyrene	0.01	mg/kg	-	-	96*	100	1.2	1.5	0.056	2.8	1.7	5.2	19
Carcinogenic PAHs													
Benzo[a]anthracene	0.01	mg/kg	0.1	-	-	10	0.84	0.99	nd	1.2	0.95	2.0	6.8
Benzo[a]pyrene	0.01	mg/kg	1	-	-	72	0.64	0.67	nd	0.89	0.65	1.5	6.6
Benzo[b]fluoranthene	0.01	mg/kg	0.1	-	-	10	0.64	0.62	nd	0.62	0.40	1.2	4.8
Benzo[ghi]perylene	0.01	mg/kg	0.01	-	-	-	0.54	0.52	nd	0.53	0.33	1.0	4.5
Benzo[j]fluoranthene	0.01	mg/kg	0.1	-	-	10	0.34	0.33	nd	0.39	0.24	0.71	3.1
Benzo[k]fluoranthene	0.01	mg/kg	0.1	-	-	10	0.33	0.33	nd	0.35	0.23	0.67	2.8
Chrysene	0.01	mg/kg	0.01	-	-	-	0.94	1.1	nd	1.2	0.78	2.3	7.3
Indeno[1,2,3-cd]pyrene	0.01	mg/kg	0.1	-	-	10	0.43	0.43	nd	0.37	0.24	0.72	3.4
Dibenz[a,h]anthracene	0.01	mg/kg	1	-	-	10	0.12	0.11	nd	0.12	0.079	0.20	0.9
Benzo(a)pyrene TPE concentration				5.3[1,5]	-	-	1.0	1.1	0.013	1.3	0.9	2.3	**9.7**

Notes:

1 = Canadian Counsel of Ministers of the Environment (CCME) Soil Quality Guidelines for the Protection of Environmental and Human Health (CSQG on-line 2013). As per CCME recommendations, soil samples are compared against the soil quality guidelines for the protection of human health and environmental health separately. Commercial land use.

2 = Human Health Criteria for non-carcinogenic PAHs in soil. Guidelines from other jurisdictions applied in the absence of applicable CCME guidelines. Source guideline for specific PAH parameter:*Ontario Ministry of the Environment (MOE) Soil, Groundwater and Sediment Standards for Use Under Part XV.I of the Environmental Protection Act April 15, 2011. Soil Components for Table 3 – Full Depth, Non-potable Scenario (lowest applicable human health guideline); **Texas Risk Reduction Program (TRRP) Tier I protective concentration level (PCL), Table 5 (June 2012).

3 = Carcinogenic PAHs assessed as B[a]P TPE for Human Health

4 = Guideline if potential impact to surface water (freshwater)

5 = Based on CCME guidelines for ingestion, inhalation and dermal exposures. Where a parameter is not detected, 1/2 of the RDL is used in the TPE calculation.

B[a]P TPE = Benzo(a)pyrene Total Potency Equivalent concentration. Calculation assumes that soil is not contaminated with coal tar or creosote timbers

B(a)P PEF = Benzo(a)pyrene Potency Equivalent Factor

TPE = Total potency equivalent

RDL = Reportable Detection Limit for routine analysis

nd = not detected above standard RDL

" - " = no guideline available

mbgs = metres below ground surface

Bold/Shaded = Value exceeds applicable guideline

Lab-Dup = Laboratory QA/QC duplicate sample

Table B.4 Results of Laboratory Analysis of Polycyclic Aromatic Hydrocarbons in Soil (cont.)
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameter	RDL	Units	B(a)P PEF	CCME $CSQG_{HH}$[1] (All Land Uses)	HH Guidelines - Other Jurisdictions[2] (All Land Uses)	CCME $CSQG_{EH}$[1] - (Comm.)	BH5-SS4	BH5-SS4 Lab-Dup	BH6-SS4	BH7-SS1	BH7-SS6	BH8-SS4	BH9-SS2
							2.1 - 2.7 mbgs	-	2.9 - 3.5 mbgs	0.2 - 0.7 mbgs	3.4 - 4.0 mbgs	2.1 - 2.7 mbgs	0.8 - 1.4 mbgs
							21-Feb-13	-	25-Feb-13	25-Feb-13	25-Feb-13	20-Feb-13	24-Feb-13
Non-Carcinognic PAHs													
1-Methylnaphthalene	0.01	mg/kg	-	-	560*	-	0.23	0.31	2.5	nd	nd	0.021	nd
2-Methylnaphthalene	0.01	mg/kg	-	-	560*	-	0.19	0.28	1.6	nd	nd	0.033	nd
Acenaphthene	0.01	mg/kg	-	-	96*	-	0.56	1.9	0.2	nd	0.039	0.015	nd
Acenaphthylene	0.01	mg/kg	-	-	9.6*	-	0.085	0.14	0.27	nd	nd	nd	nd
Anthracene	0.01	mg/kg	-	-	4,200*	32	4.3	15	0.35	nd	nd	nd	nd
Fluoranthene	0.01	mg/kg	-	-	9.6*	180	**12**	**44**	0.84	0.014	nd	0.065	0.017
Fluorene	0.01	mg/kg	-	-	5,600*	-	1.9	6.7	0.78	nd	0.033	0.024	nd
Naphthalene	0.01	mg/kg	-	-	2,800*	22/0.013[4]	0.24	0.39	1.1	nd	nd	0.35	nd
Perylene	0.01	mg/kg	-	-	2,800**	-	1.1	2.7	0.22	nd	0.014	nd	nd
Phenanthrene	0.01	mg/kg	-	-	3,800**	50/0.046[4]	8.9	19	1.6	0.026	nd	0.074	0.024
Pyrene	0.01	mg/kg	-	-	96*	100	12	45	0.83	0.014	nd	0.081	0.016
Carcinogenic PAHs													
Benzo[a]anthracene	0.01	mg/kg	0.1	-	-	10	5.8	**22**	0.52	nd	nd	0.036	nd
Benzo[a]pyrene	0.01	mg/kg	1	-	-	72	5.0	17	0.53	nd	nd	0.040	nd
Benzo[b]fluoranthene	0.01	mg/kg	0.1	-	-	10	3.2	9.8	0.40	nd	nd	0.029	nd
Benzo[ghi]perylene	0.01	mg/kg	0.01	-	-	-	2.1	7.3	0.36	nd	nd	0.028	nd
Benzo[j]fluoranthene	0.01	mg/kg	0.1	-	-	10	2.2	6.9	0.32	nd	nd	0.019	nd
Benzo[k]fluoranthene	0.01	mg/kg	0.1	-	-	10	2.0	6.2	0.25	nd	nd	0.017	nd
Chrysene	0.01	mg/kg	0.01	-	-	-	5.9	21	0.64	0.018	nd	0.042	nd
Indeno[1,2,3-cd]pyrene	0.01	mg/kg	0.1	-	-	10	1.8	5.9	0.31	nd	nd	0.022	nd
Dibenz[a,h]anthracene	0.01	mg/kg	1	-	-	10	0.62	1.7	0.081	nd	nd	nd	nd
Benzo(a)pyrene TPE concentration				5.3[1,5]	-	-	**7.2**	**24.1**	0.801	0.013	0.013	0.058	0.013

Notes:

1 = Canadian Counsel of Ministers of the Environment (CCME) Soil Quality Guidelines for the Protection of Environmental and Human Health (CSQG on-line 2013). As per CCME recommendations, soil samples are compared against the soil quality guidelines for the protection of human health and environmental health separately. Commercial land use.

2 = Human Health Criteria for non-carcinogenic PAHs in soil. Guidelines from other jurisdictions applied in the absence of applicable CCME guidelines. Source guideline for specific PAH parameter:*Ontario Ministry of the Environment (MOE) Soil, Groundwater and Sediment Standards for Use Under Part XV.I of the Environmental Protection Act April 15, 2011. Soil Components for Table 3 – Full Depth, Non-potable Scenario (lowest applicable human health guideline); **Texas Risk Reduction Program (TRRP) Tier I protective concentration level (PCL), Table 5 (June 2012).

3 = Carcinogenic PAHs assessed as B[a]P TPE for Human Health

4 = Guideline if potential impact to surface water (freshwater)

5 = Based on CCME guidelines for ingestion, inhalation and dermal exposures. Where a parameter is not detected, 1/2 of the RDL is used in the TPE calculation.

B[a]P TPE = Benzo(a)pyrene Total Potency Equivalent concentration. Calculation assumes that soil is not contaminated with coal tar or creosote timbers

B(a)P PEF = Benzo(a)pyrene Potency Equivalent Factor

TPE = Total potency equivalent

RDL = Reportable Detection Limit for routine analysis

nd = not detected above standard RDL

" - " = no guideline available

mbgs = metres below ground surface

Bold/Shaded = Value exceeds applicable guideline

Lab-Dup = Laboratory QA/QC duplicate sample

Table B.4 Results of Laboratory Analysis of Polycyclic Aromatic Hydrocarbons in Soil (cont.)
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameter	RDL	Units	B(a)P PEF	CCME $CSQG_{HH}$[1] (All Land Uses)	HH Guidelines - Other Jurisdictions[2] (All Land Uses)	CCME $CSQG_{EH}$[1] - (Comm.)	BH10-SS1	BH11-SS1	BH12-SS2	BH13-SS3	BH13-SS3 Lab-Dup	BH13-SS5
							0.4 - 1.2 mbgs	0.3 - 0.8 mbgs	1.0 - 1.3 mbgs	1.3 - 1.9 mbgs	-	2.1 - 3.2 mbgs
							05-Mar-13	07-Mar-13	03-Mar-13	22-Feb-13	-	22-Feb-13
Non-Carcinognic PAHs												
1-Methylnaphthalene	0.01	mg/kg	-	-	560*	-	0.11	nd	0.34	0.011	0.013	0.054
2-Methylnaphthalene	0.01	mg/kg	-	-	560*	-	0.17	nd	0.42	0.016	0.018	0.097
Acenaphthene	0.01	mg/kg	-	-	96*	-	0.36	nd	1.3	nd	nd	0.087
Acenaphthylene	0.01	mg/kg	-	-	9.6*	-	0.034	nd	0.078	nd	nd	nd
Anthracene	0.01	mg/kg	-	-	4,200*	32	0.51	nd	2.2	0.019	0.024	0.08
Fluoranthene	0.01	mg/kg	-	-	9.6*	180	2.1	0.062	9.3	0.15	0.17	0.5
Fluorene	0.01	mg/kg	-	-	5,600*	-	0.5	nd	1.4	nd	nd	0.069
Naphthalene	0.01	mg/kg	-	-	2,800*	22/0.013[4]	0.34	nd	0.58	0.013	0.014	0.057
Perylene	0.01	mg/kg	-	-	2,800**	-	0.089	nd	0.49	0.026	0.029	0.073
Phenanthrene	0.01	mg/kg	-	-	3,800**	50/0.046[4]	2.1	0.031	11	0.094	0.1	0.25
Pyrene	0.01	mg/kg	-	-	96*	100	1.6	0.056	7.1	0.13	0.14	0.44
Carcinogenic PAHs												
Benzo[a]anthracene	0.01	mg/kg	0.1	-	-	10	0.59	0.033	4.0	0.076	0.086	0.23
Benzo[a]pyrene	0.01	mg/kg	1	-	-	72	0.380	0.027	2.4	0.095	0.110	0.280
Benzo[b]fluoranthene	0.01	mg/kg	0.1	-	-	10	0.32	0.026	1.7	0.076	0.086	0.22
Benzo[ghi]perylene	0.01	mg/kg	0.01	-	-	-	0.18	0.025	1.0	0.074	0.083	0.21
Benzo[j]fluoranthene	0.01	mg/kg	0.1	-	-	10	0.19	0.015	1.1	0.045	0.051	0.13
Benzo[k]fluoranthene	0.01	mg/kg	0.1	-	-	10	0.18	0.013	1.1	0.042	0.049	0.12
Chrysene	0.01	mg/kg	0.01	-	-	-	0.64	0.047	4.0	0.083	0.09	0.24
Indeno[1,2,3-cd]pyrene	0.01	mg/kg	0.1	-	-	10	0.17	0.017	0.95	0.061	0.07	0.17
Dibenz[a,h]anthracene	0.01	mg/kg	1	-	-	10	0.049	nd	0.32	0.015	0.016	0.045
Benzo(a)pyrene TPE concentration				5.3[1,5]	-	-	0.58	0.043	3.7	0.14	0.16	0.42

Notes:

1 = Canadian Counsel of Ministers of the Environment (CCME) Soil Quality Guidelines for the Protection of Environmental and Human Health (CSQG on-line 2013). As per CCME recommendations, soil samples are compared against the soil quality guidelines for the protection of human health and environmental health separately. Commercial land use.

2 = Human Health Criteria for non-carcinogenic PAHs in soil. Guidelines from other jurisdictions applied in the absence of applicable CCME guidelines. Source guideline for specific PAH parameter:*Ontario Ministry of the Environment (MOE) Soil, Groundwater and Sediment Standards for Use Under Part XV.I of the Environmental Protection Act April 15, 2011. Soil Components for Table 3 – Full Depth, Non-potable Scenario (lowest applicable human health guideline); **Texas Risk Reduction Program (TRRP) Tier I protective concentration level (PCL), Table 5 (June 2012).

3 = Carcinogenic PAHs assessed as B[a]P TPE for Human Health

4 = Guideline if potential impact to surface water (freshwater)

5 = Based on CCME guidelines for ingestion, inhalation and dermal exposures. Where a parameter is not detected, 1/2 of the RDL is used in the TPE calculation.

B[a]P TPE = Benzo(a)pyrene Total Potency Equivalent concentration. Calculation assumes that soil is not contaminated with coal tar or creosote timbers

B(a)P PEF = Benzo(a)pyrene Potency Equivalent Factor

TPE = Total potency equivalent

RDL = Reportable Detection Limit for routine analysis

nd = not detected above standard RDL

" - " = no guideline available

mbgs = metres below ground surface

Bold/Shaded = Value exceeds applicable guideline

Lab-Dup = Laboratory QA/QC duplicate sample

Table B.4 Results of Laboratory Analysis of Polycyclic Aromatic Hydrocarbons in Soil (cont.)
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameter	RDL	Units	B(a)P PEF	CCME $CSQG_{HH}$[1] (All Land Uses)	HH Guidelines - Other Jurisdictions[2] (All Land Uses)	CCME $CSQG_{EH}$[1] - (Comm.)	BH14-SS3	BH14-AS3C	BH15-SS1	BH15-SS3
							1.6 - 2.2 mbgs	2.3 mbgs	0.2 - 0.8 mbgs	1.6 - 2.2 mbgs
							24-Feb-13	24-Feb-13	26-Feb-13	26-Feb-13
Non-Carcinognic PAHs										
1-Methylnaphthalene	0.01	mg/kg	-	-	560*	-	8.1	0.011	nd	2.6
2-Methylnaphthalene	0.01	mg/kg	-	-	560*	-	13	0.014	nd	0.13
Acenaphthene	0.01	mg/kg	-	-	96*	-	12	nd	nd	0.36
Acenaphthylene	0.01	mg/kg	-	-	9.6*	-	5.0	nd	nd	0.33
Anthracene	0.01	mg/kg	-	-	4,200*	32	20	nd	nd	0.12
Fluoranthene	0.01	mg/kg	-	-	9.6*	180	**64**	0.04	nd	0.64
Fluorene	0.01	mg/kg	-	-	5,600*	-	21	0.01	nd	0.78
Naphthalene	0.01	mg/kg	-	-	2,800*	22/0.013[4]	**38**	0.01	nd	0.066
Perylene	0.01	mg/kg	-	-	2,800**	-	3.6	0.035	nd	0.047
Phenanthrene	0.01	mg/kg	-	-	3,800**	50/0.046[4]	**100**	0.04	nd	0.95
Pyrene	0.01	mg/kg	-	-	96*	100	52	0.12	nd	0.65
Carcinogenic PAHs										
Benzo[a]anthracene	0.01	mg/kg	0.1	-	-	10	**25**	nd	nd	0.28
Benzo[a]pyrene	0.01	mg/kg	1	-	-	72	16	0.044	nd	0.22
Benzo[b]fluoranthene	0.01	mg/kg	0.1	-	-	10	**11**	nd	nd	0.2
Benzo[ghi]perylene	0.01	mg/kg	0.01	-	-	-	7.5	0.11	nd	0.12
Benzo[j]fluoranthene	0.01	mg/kg	0.1	-	-	10	7.0	nd	nd	0.12
Benzo[k]fluoranthene	0.01	mg/kg	0.1	-	-	10	6.5	nd	nd	0.12
Chrysene	0.01	mg/kg	0.01	-	-	-	23	0.56	0.014	0.32
Indeno[1,2,3-cd]pyrene	0.01	mg/kg	0.1	-	-	10	6.7	nd	nd	0.11
Dibenz[a,h]anthracene	0.01	mg/kg	1	-	-	10	2.0	nd	nd	0.031
Benzo(a)pyrene TPE concentration				5.3[1,5]	-	-	**23.9**	0.06	0.013	0.34

Notes:

1 = Canadian Counsel of Ministers of the Environment (CCME) Soil Quality Guidelines for the Protection of Environmental and Human Health (CSQG on-line 2013). As per CCME recommendations, soil samples are compared against the soil quality guidelines for the protection of human health and environmental health separately. Commercial land use.

2 = Human Health Criteria for non-carcinogenic PAHs in soil. Guidelines from other jurisdictions applied in the absence of applicable CCME guidelines. Source guideline for specific PAH parameter:*Ontario Ministry of the Environment (MOE) Soil, Groundwater and Sediment Standards for Use Under Part XV.I of the Environmental Protection Act April 15, 2011. Soil Components for Table 3 – Full Depth, Non-potable Scenario (lowest applicable human health guideline); **Texas Risk Reduction Program (TRRP) Tier I protective concentration level (PCL), Table 5 (June 2012).

3 = Carcinogenic PAHs assessed as B[a]P TPE for Human Health

4 = Guideline if potential impact to surface water (freshwater)

5 = Based on CCME guidelines for ingestion, inhalation and dermal exposures. Where a parameter is not detected, 1/2 of the RDL is used in the TPE calculation.

B[a]P TPE = Benzo(a)pyrene Total Potency Equivalent concentration. Calculation assumes that soil is not contaminated with coal tar or creosote timbers

B(a)P PEF = Benzo(a)pyrene Potency Equivalent Factor

TPE = Total potency equivalent

RDL = Reportable Detection Limit for routine analysis

nd = not detected above standard RDL

" - " = no guideline available

mbgs = metres below ground surface

Bold/Shaded = Value exceeds applicable guideline

Table B.5 Results of Laboratory Analysis of Polychlorinated Biphenyls in Soil
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Sample I.D.	Depth (mbgs)	Date	Polychlorinated Biphenyls (PCBs)
BH1-SS3	1.6 - 2.2	04-Mar-13	nd
BH1-SS3 Lab-Dup	-	-	nd
BH1-SS9	5.7 - 6.3	04-Mar-13	nd
BH2-SS5	2.9 - 3.6	27-Feb-13	nd
BH3-SS4	2.6 - 3.2	06-Mar-13	nd
BH4-SS5	2.2 - 2.6	28-Feb-13	nd
BH4-SS5 Lab-Dup	-	-	nd
BH5-SS4	2.1 - 2.7	21-Feb-13	nd
BH5-SS4 Lab-Dup	-	-	nd
BH6-SS4	2.9 - 3.5	25-Feb-13	nd
BH7-SS1	0.2 - 0.7	25-Feb-13	nd
BH7-SS6	3.4 - 4.0	25-Feb-13	nd
BH8-SS4	2.1 - 2.7	20-Feb-13	nd
BH9-SS2	0.8 - 1.4	24-Feb-13	nd
BH10-SS1	0.4 - 1.2	05-Mar-13	nd
BH11-SS1	0.3 - 0.8	07-Mar-13	nd
BS12-SS2	1.0 - 1.3	03-Mar-13	nd
BH13-SS3	1.3 - 1.9	22-Feb-13	nd
BH14-SS3	1.6 - 3.2	24-Feb-13	nd
BH14-AS3C	2.3	24-Feb-13	nd
BH15-SS1	0.2 - 0.8	26-Feb-13	nd
BH15-SS1 Lab-Dup	-	-	nd
BH15-SS3	1.6 - 2.2	26-Feb-13	nd
		RDL	0.05
		Units	mg/kg
		Guideline[1]	33

Notes:
1 = Canadian Council of Ministers of the Environment (CCME) Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CSQG on-line 2013). Commercial land use.

RDL = Reportable Detection Limit for routine analysis
nd = Not detected above standard RDL
mbgs = metres below ground surface
Lab-Dup = Laboratory QA/QC duplicate sample

Table B.6 Results of Laboratory Analysis of Total Oil and Grease in Soil
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Sample I.D.	Depth (mbgs)	Date	Total Oil & Grease
BH2-SS5	2.9 - 3.6	27-Feb-13	1,800
BH5-SS4	2.1 - 2.7	21-Feb-13	1,400
BH6-SS4	2.9 - 3.5	25-Feb-13	5,200
BH8-SS4	2.1 - 2.7	20-Feb-13	660
BH8-SS4 Lab-Dup	-	-	600
BH13-SS5	2.1 - 3.2	22-Feb-13	480
BH15-SS3	1.6 - 2.2	26-Feb-13	3,500
		RDL	0.05
		Units	mg/kg

Notes:
RDL = Reportable Detection Limit for routine analysis
nd = Not detected above standard RDL
mbgs = metres below ground surface
Lab-Dup = Laboratory QA/QC duplicate sample

Table B.7 Results of Laboratory Analysis of Leachate in Soil
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameters	Units	Guideline[1]	RDL	BH6-SS4	BH14-SS3	BH14-SS3 Lab-Dup	BH14-AS3C	BH14-AS3C Lab-Dup	BH15-SS3
				2.9 - 3.5 mbgs	1.6 - 2.2 mbgs	-	2.3 mbgs	-	1.6 - 2.2 mbgs
				25-Feb-13	24-Feb-13	-	24-Feb-13	-	26-Feb-13
Leachable >C10-C16 Hydrocarbons	µg/L	-	0.20	1.1	1.7	1.7	nd	-	0.92
Leachable >C16-C21 Hydrocarbons	µg/L	-	0.20	nd	0.46	0.47	nd	-	nd
Leachable >C21-<C32 Hydrocarbons	µg/L	-	0.50	nd	nd	nd	nd	-	nd
Leachable Lead	µg/L	5,000	5.0	410	2,200	-	10	-	540
Leachable Fluoranthene	µg/L	-	0.10	0.21	8.5	-	nd	nd	0.30
Leachable Naphthalene	µg/L	-	2.0	8.4	600	-	nd	nd	nd
Leachable Phenanthrene	µg/L	-	0.10	1.5	93	-	0.20	0.24	1.7

Notes:
1 = Environment Canada, Interprovincial Movement of Hazardous Waste and Hazardous Recyclable Material Regulations, Schedule 2 (Table of Hazardous Constituents Controlled Under Leachate Test and Regulated Limits), January 2002

RDL = Reportable Detection Limit
nd = Not detected above standard RDL
'-' = no applicable guidelines
Lab-Dup = Laboratory QA/QC duplicate sample

Table B.8 Results of Laboratory Analysis of Petroleum Hydrocarbons in Groundwater
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameters	RDL	Units	FIGQGs[1]	ON MOE[2]	BH1	BH2	BH4	BH5	BH7	BH8	BH11	BH13	BH15
					12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13
Benzene	0.001	mg/L	0.2	0.044	nd	nd	0.002	nd	nd	nd	0.003	nd	nd
Toluene	0.001	mg/L	8.9	14	nd	nd	nd	nd	nd	nd	0.002	nd	nd
Ethylbenzene	0.001	mg/L	11	1.8	nd	nd	nd	nd	nd	nd	0.004	nd	nd
Xylenes	0.002	mg/L	-	3.3	nd	nd	nd	nd	nd	nd	0.011	nd	nd
C_6-C_{10} - F1	0.01	mg/L	-	0.42	nd	0.017	0.064	nd	nd	0.079	0.2	nd	0.20
C_{10}-C_{16} - F2	0.05	mg/L	-	0.15	0.085	0.068	0.13	0.055	0.15	**1.2**	**0.28**	0.088	**1.1**
C_{16}-C_{32}[4] - F3	0.1	mg/L	-	0.5	nd	nd	nd	0.165	0.085	**0.63**	0.061	nd	0.25
>C_{32}[4] - F4	-	mg/L	-	0.5	-	-	-	-	-	-	-	-	-
Modified TPH - Tier I[3]	0.1	mg/L	-	-	nd	nd	0.19	0.22*	0.23	1.9*	0.54	nd	1.5
Resemblance	-	-	-	-	NR FO	G/FO	G/FO	NR FO/LO	FO	FO	G	FO	G/FO

Notes:

1 = Federal Interim Groundwater Quality Guidelines (FIGQGs), Generic Guidelines for Commercial and Industrial Land Uses (November 2012), Tier 2 for Marine Life Water Use (Table 3)

2 = Ontario Ministry of the Environment (MOE) Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the *Environmental Protection Act.* April 15, 2011. Generic site condition standards for use within 30 m of a water body in a non-potable groundwater condition (Table 9)

3 = Modified TPH - Tier I does not include BTEX

4 = Atlantic PIRI analytical method does not analyse for >C32. Laboratory certificate indicates (Yes or No) whether chromatogram for each sample returns to baseline after C32. Samples are considered to have returned to baseline if the area from C32-C36 is less than 10% of the area from C10-C32.

* = Baseline not reached at C32; sample may contain carbon fractions >C32

Bold/shaded/underlined = exceeds ON MOE criteria

RDL = Reportable Detection Limit

nd = Not detected above standard RDL

na = Not applicable

G = Gasoline; FO = fuel oil; LO = lube oil; NR = no resemblance to petroleum hydrocarbons

Table B.9 Results of Laboratory Analysis of Fractionated Petroleum Hydrocarbons in Groundwater
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameters	RDL	Units	FIGQGs[1]	ON MOE[2]	BH6	BH6 Lab-Dup	BH15
					12-Mar-13		13-Mar-13
Benzene	0.001	mg/L	0.2	0.044	0.016	-	nd
Toluene	0.001	mg/L	8.9	18	0.0038	-	nd
Ethylbenzene	0.001	mg/L	11	2.3	0.067	-	nd
Xylenes	0.002	mg/L	-	4.2	0.12	-	0.0030
Aliphatic >C6-C8	0.010	mg/L	-	-	0.47	-	0.13
Aliphatic >C8-C10	0.010	mg/L	-	-	0.12	-	0.091
>C8-C10 Aromatics (-EX)	0.010	mg/L	-	-	0.62	-	0.045
Aliphatic >C10-C12	0.010	mg/L	-	-	0.12	0.096	0.35
Aliphatic >C12-C16	0.050	mg/L	-	-	0.26	0.23	0.78
Aliphatic >C16-C21	0.050	mg/L	-	-	0.14	0.13	0.32
Aliphatic >C21-<C32	0.100	mg/L	-	-	nd	nd	nd
Aromatic >C10-C12	0.010	mg/L	-	-	0.54	0.46	0.19
Aromatic >C12-C16	0.050	mg/L	-	-	0.33	0.29	0.31
Aromatic >C16-C21	0.050	mg/L	-	-	0.17	0.15	0.19
Aromatic >C21-<C32	0.100	mg/L	-	-	nd	nd	nd
C_6-C_{10} - F1	-	mg/L	-	0.75	**<u>1.21</u>**	-	0.27
C_{10}-C_{16} - F2	-	mg/L	-	0.15	**<u>1.25</u>**	-	**<u>1.63</u>**
C_{16}-C_{32}[4] - F3	-	mg/L	-	0.5	0.41	-	**<u>0.61</u>**
>C_{32}[4] - F4	-	mg/L	-	0.5	-	-	-
Modified TPH - Tier 2[3]	0.11	mg/L	-	-	2.8	-	2.4
Resemblance	-	-	-	-	G, WFO	-	WFO

Notes:

1 = Federal Interim Groundwater Quality Guidelines (FIGQGs), Generic Guidelines for Commercial and Industrial Land Uses (November 2012), Tier 2 for Marine Life Water Use (Table 3)

2 = Ontario Ministry of the Environment (MOE) Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the *Environmental Protection Act.* April 15, 2011. Generic site condition standards for use within 30 m of a water body in a non-potable groundwater condition (Table 9)

3 = Modified TPH - Tier I does not include BTEX

4 = Atlantic PIRI analytical method does not analyse for >C32. Laboratory certificate indicates (Yes or No) whether chromatogram for each sample returns to baseline after C32. Samples are considered to have returned to baseline if the area from C32-C36 is less than 10% of the area from C10-C32.

<u>Bold/shaded/underlined = exceeds ON MOE criteria</u>

RDL = Reportable Detection Limit

nd = Not detected above standard RDL

Lab-Dup = Laboratory QA/QC duplicate sample

na = Not applicable

G = Gasoline; WFO = weathered fuel oil

Table B.10 Results of Laboratory Analysis of Dissolved Metals in Groundwater
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameters	RDL	Units	FIGQGs[1]	ON MOE[2]	BH1	BH2	BH4	BH5	BH6
					12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13
Aluminum	5.0	ug/L	-	-	nd	nd	nd	11.2	7.6
Antimony	1.0	ug/L	-	16,000	nd	nd	nd	nd	nd
Arsenic	1.0	ug/L	12.5	1,500	nd	1.0	nd	nd	nd
Barium	1.0	ug/L	500	23,000	36.2	264	427	72.9	86.1
Beryllium	1.0	ug/L	100	53	nd	nd	nd	nd	nd
Bismuth	2.0	ug/L	-	-	nd	nd	nd	nd	nd
Boron	50	ug/L	5,000	36,000	150	371	425	nd	nd
Cadmium	0.017	ug/L	0.12	2.1	0.028	nd	nd	0.033	0.017
Calcium	100	ug/L	-	-	35,900	88,300	149,000	11,400	22,400
Chromium	1.0	ug/L	56	640	nd	nd	nd	nd	nd
Cobalt	0.40	ug/L	-	52	1.32	3.15	1.57	1.32	5.67
Copper	2.0	ug/L	2.0	69	nd	nd	nd	nd	nd
Iron	50	ug/L	-	-	nd	8120	15100	nd	1220
Lead	0.50	ug/L	2.0	20	nd	nd	nd	nd	0.53
Magnesium	100	ug/L	-	-	52,500	164,000	215,000	5,490	5,690
Manganese	2.0	ug/L	-	-	395	11900	14500	126	1880
Mercury	0.013	ug/L	0.016	0.29	**0.053**	**0.050**	nd	**0.10**	nd
Molybdenum	2.0	ug/L	-	7,300	2.2	3.1	2.2	nd	nd
Nickel	2.0	ug/L	83	390	3.6	nd	nd	4.1	4.8
Phosphorus	100	ug/L	-	-	nd	nd	nd	nd	nd
Potassium	100	ug/L	-	-	12600	36,900	45,100	2,170	2,940
Selenium	1.0	ug/L	54	50	nd	nd	nd	nd	nd
Silver	0.10	ug/L	1.5	1.2	nd	nd	nd	nd	nd
Sodium	100	ug/L	-	180,000	**<u>414,000</u>**	**<u>1,240,000</u>**	**<u>1,570,000</u>**	75,200	94,400
Strontium	2.0	ug/L	-	-	429	1270	1750	62	91.3
Thallium	0.10	ug/L	-	400	nd	nd	nd	nd	nd
Tin	2.0	ug/L	-	-	nd	nd	nd	nd	nd
Titanium	2.0	ug/L	-	-	nd	nd	nd	nd	nd
Uranium	0.10	ug/L	-	330	nd	0.12	1.76	nd	nd
Vanadium	2.0	ug/L	-	200	nd	nd	nd	nd	nd
Zinc	5.0	ug/L	10	890	6.5	nd	nd	**10.8**	9.5

Notes:

1 = Federal Interim Groundwater Quality Guidelines (FIGQGs), Generic Guidelines for Commercial and Industrial Land Uses (November 2012), Tier 2 for Marine Life Water Use (Table 3)

2 = Ontario Ministry of the Environment (MOE) Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the *Environmental Protection Act.* April 15, 2011. Generic site condition standards for use within 30 m of a water body in a non-potable groundwater condition (Table 9)

RDL = Reportable Detection Limit for routine analysis

nd = Not detected above standard RDL

"-" = No applicable guideline

na = Not available

Bold/shaded = exceeds FIGQG criteria

<u>Bold/shaded/underlined = exceeds ON MOE criteria</u>

Table B.10 Results of Laboratory Analysis of Dissolved Metals in Groundwater (cont.)
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameters	RDL	Units	FIGQGs[1]	ON MOE[2]	BH7	BH8	BH11	BH13	BH15
					12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	13-Mar-13
Aluminum	5.0	ug/L	-	-	14.2	5.9	51.9	nd	11.2
Antimony	1.0	ug/L	-	16,000	nd	nd	1	nd	nd
Arsenic	1.0	ug/L	12.5	1,500	nd	nd	5.9	nd	3.0
Barium	1.0	ug/L	500	23,000	94.4	19.7	**750**	61.9	10.4
Beryllium	1.0	ug/L	100	53	nd	nd	nd	nd	nd
Bismuth	2.0	ug/L	-	-	nd	nd	nd	nd	nd
Boron	50	ug/L	5,000	36,000	nd	nd	nd	697	nd
Cadmium	0.017	ug/L	0.12	2.1	0.078	nd	nd	0.037	nd
Calcium	100	ug/L	-	-	41,400	11,300	61,400	78,900	10,600
Chromium	1.0	ug/L	56	640	nd	nd	nd	nd	nd
Cobalt	0.40	ug/L	-	52	3.11	1.55	nd	2.63	nd
Copper	2.0	ug/L	2.0	69	**3.6**	nd	**2.3**	nd	nd
Iron	50	ug/L	-	-	nd	621	nd	nd	nd
Lead	0.50	ug/L	2.0	20	nd	nd	nd	nd	1.00
Magnesium	100	ug/L	-	-	6,810	2,320	5,160	141,000	3,900
Manganese	2.0	ug/L	-	-	164	389	7.3	1340	234
Mercury	0.013	ug/L	0.016	0.29	**0.022**	**<u>0.35</u>**	**0.041**	**0.18**	**<u>1.3</u>**
Molybdenum	2.0	ug/L	-	7,300	nd	2.5	7	nd	nd
Nickel	2.0	ug/L	83	390	10.2	9.9	nd	7.4	nd
Phosphorus	100	ug/L	-	-	nd	nd	103	nd	nd
Potassium	100	ug/L	-	-	4,710	2,020	4,180	46,200	3,130
Selenium	1.0	ug/L	54	50	nd	nd	nd	nd	nd
Silver	0.10	ug/L	1.5	1.2	nd	nd	nd	nd	nd
Sodium	100	ug/L	-	180,000	**<u>277,000</u>**	52,500	**<u>378,000</u>**	**<u>1,410,000</u>**	58,800
Strontium	2.0	ug/L	-	-	163	46	277	860	48.6
Thallium	0.10	ug/L	-	400	nd	nd	nd	nd	nd
Tin	2.0	ug/L	-	-	nd	nd	nd	nd	nd
Titanium	2.0	ug/L	-	-	nd	nd	nd	nd	nd
Uranium	0.10	ug/L	-	330	nd	nd	1.8	0.22	nd
Vanadium	2.0	ug/L	-	200	nd	nd	4.6	nd	nd
Zinc	5.0	ug/L	10	890	**43.6**	7.2	nd	**23.4**	5.6

Notes:

1 = Federal Interim Groundwater Quality Guidelines (FIGQGs), Generic Guidelines for Commercial and Industrial Land Uses (November 2012), Tier 2 for Marine Life Water Use (Table 3)

2 = Ontario Ministry of the Environment (MOE) Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the *Environmental Protection Act.* April 15, 2011. Generic site condition standards for use within 30 m of a water body in a non-potable groundwater condition (Table 9)

RDL = Reportable Detection Limit for routine analysis

nd = Not detected above standard RDL

"-" = No applicable guideline

na = Not available

Bold/shaded = exceeds FIGQG criteria

<u>Bold/shaded/underlined = exceeds ON MOE criteria</u>

Table B.11 Results of Laboratory Analysis of Polycyclic Aromatic Hydrocarbons in Groundwater
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameters	RDL	Units	FIGQGs[1]	ON MOE[2]	BH1	BH2	BH4	BH5	BH6	BH7	BH8	BH11	BH13	BH15
					12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	13-Mar-13
1-Methylnaphthalene	0.05	ug/L	-	1,500	2.7	0.32	nd	0.13	13	nd	0.14	2.0	0.20	1.7
2-Methylnaphthalene	0.05	ug/L	-	1,500	4.0	0.20	nd	0.15	4.4	nd	nd	1.4	0.081	nd
Acenaphthene	0.01	ug/L	-	600	4.5	0.27	0.3	nd	0.36	0.012	nd	0.28	0.50	0.29
Acenaphthylene	0.01	ug/L	-	1.4	0.74	0.085	nd	0.038	nd	0.021	nd	nd	nd	nd
Anthracene	0.01	ug/L	-	1.0	**9.1**	0.46	nd	**1.8**	nd	0.029	nd	nd	0.30	nd
Benzo(a)anthracene	0.01	ug/L	-	1.8	**12**	0.63	0.011	**3.4**	0.013	0.12	0.58	0.021	0.25	0.026
Benzo(a)pyrene	0.01	ug/L	-	0.81	**7.9**	0.53	nd	**2.3**	nd	0.098	0.53	0.012	0.20	0.021
Benzo(b)fluoranthene	0.01	ug/L	-	0.75	**5.4**	0.41	nd	**1.6**	nd	0.079	0.40	0.011	0.16	0.019
Benzo(g,h,i)perylene	0.01	ug/L	-	0.2	**3.8**	**0.34**	nd	**1.0**	nd	0.06	**0.33**	0.01	0.12	0.015
Benzo(j)fluoranthene	0.01	ug/L	-	na	3.4	0.25	nd	1.0	nd	0.046	0.25	nd	0.094	0.011
Benzo(k)fluoranthene	0.01	ug/L	-	0.4	**3.2**	0.23	nd	**1.0**	nd	0.043	0.22	nd	0.086	nd
Chrysene	0.01	ug/L	-	0.7	**11**	0.67	0.011	**3.3**	0.018	0.13	**0.71**	0.03	0.26	0.031
Dibenzo(a,h,)anthracene	0.01	ug/L	-	0.4	**0.89**	0.085	nd	0.26	nd	0.015	0.077	nd	0.029	nd
Fluoranthene	0.01	ug/L	-	73	30	1.9	0.037	7.7	0.054	0.17	1.3	0.14	1.0	0.13
Fluorene	0.01	ug/L	-	290	6.6	0.41	0.67	1.1	0.97	0.018	0.35	0.46	0.40	0.56
Indeno(1,2,3-c,d) pyrene	0.01	ug/L	-	0.2	**2.9**	**0.25**	nd	**0.73**	nd	0.044	**0.25**	nd	0.093	0.011
Naphthalene	0.20	ug/L	1.4	1,400	**6.8**	0.33	nd	0.26	**13**	nd	nd	**3.6**	nd	nd
Perylene	0.01	ug/L	-	na	1.7	0.13	nd	0.45	nd	0.023	0.13	nd	0.07	nd
Phenanthrene	0.01	ug/L	-	380	35	0.99	nd	4.6	0.37	0.065	0.73	0.50	1.3	0.14
Pyrene	0.01	ug/L	-	5.7	25	1.6	0.031	**7.4**	0.052	0.18	1.7	0.12	0.83	0.12

Notes:
1 = Federal Interim Groundwater Quality Guidelines (FIGQGs), Generic Guidelines for Commercial and Industrial Land Uses (November 2012), Tier 2 for Marine Life Water Use (Table 3)

2 = Ontario Ministry of the Environment (MOE) Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the *Environmental Protection Act.* April 15, 2011. Generic site condition standards for use within 30 m of a water body in a non-potable groundwater condition (Table 9)
RDL = Reportable Detection Limit
nd = Not detected above standard RDL
Bold/shaded = exceeds FIGQG criteria
Bold/shaded/underlined = exceeds ON MOE criteria
Lab report noted that the samples contained sediment.

Table B.12 Results of Laboratory Analysis of Polychlorinated Biphenyls in Groundwater
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameter		Polychlorinated Biphenyls (PCBs)
	RDL	0.05
	Units	ug/L
	ON MOE[1]	0.2
BH1	12-Mar-13	nd
BH2	12-Mar-13	nd
BH4	12-Mar-13	nd
BH5	12-Mar-13	nd
BH6	12-Mar-13	nd
BH7	12-Mar-13	nd
BH8	12-Mar-13	nd
BH11	12-Mar-13	nd
BH13	12-Mar-13	nd
BH15	13-Mar-13	nd

Notes:

1 = Ontario Ministry of the Environment (MOE) Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act. April 15, 2011. Generic site condition standards for use within 30 m of a water body in a non-potable groundwater condition (Table 9)

RDL = Reportable Detection Limit for routine analysis
nd = Not detected above standard RDL

Table B.13 Results of Laboratory Analysis of General Chemistry in Groundwater
Phase II Environmental Site Assessment
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412551

Parameters	RDL	Units	Guidelines[1]	BH1	BH1 Lab-Dup	BH2	BH4	BH5	BH6	BH7	BH8	BH11	BH13	BH15
				12-Mar-13	-	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	12-Mar-13	13-Mar-13
Alkalinity	1.0	mg/L $CaC0_3$	-	22	22	29	23	14	18	20	12	54	72	32
Sulphate	2.0	mg/L	-	71	72	270	280	20	13	25	13	13	380	17
Chloride	50	mg/L	-	580	580	2,100	2,300	140	190	490	110	550	2,500	100
Reactive Silica	0.5	mg/L SiO2	-	5.6	6.0	5.2	5.3	5.2	6.0	4.9	5.1	7.0	3.5	7.1
Orthophosphate	0.010	mg/L P	-	nd	nd	nd	nd	nd	nd	0.014	nd	0.066	nd	nd
Nitrate + Nitrite	0.050	mg/L N	-	0.18	-	nd	0.073	0.10	nd	0.15	0.11	0.083	0.10	0.083
Nitrate	0.050	mg/L N	16	0.18	-	nd	0.073	0.1	nd	0.15	0.11	0.083	0.10	0.083
Nitrite	0.010	mg/L	-	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
True Color	5.0	TCU	-	nd	nd	150	240	nd	160	nd	nd	5.8	nd	nd
Total Organic Carbon	5.0	mg/L	-	7.1	-	5.9	2.7	nd	5.5	nd	nd	nd	8.0	19
Turbidity	1.0	NTU	-	560	-	340	210	>1,000	370	>1,000	>1,000	660	380	>1,000
Conductivity	1.0	uS/cm		2,100	2,100	6,900	7,500	520	690	1,700	410	2000	8,200	430
pH	-	Units	7.0 - 8.7	7.02	7.08	**6.94**	**6.85**	**6.97**	**6.91**	7.09	**6.90**	**8.99**	7.24	7.10
Hardness	1.0	mg/L $CaC0_3$	-	310	-	900	1300	51	79	130	38	170	780	43
Bicarbonate	1.0	mg/L $CaC0_3$	-	22	-	29	23	14	18	20	12	54	72	32
Total Dissolved Solids	1.0	mg/L	-	1,180	-	3,970	4,570	266	345	859	201	1,060	4,550	220

Notes:
1 = Federal Interim Groundwater Quality Guidelines (FIGQGs), Generic Guidelines for Commercial and Industrial Land Uses (November 2012), Tier 2 for Marine Life Water Use
RDL = Reportable Detection Limit
nd = Not detected above standard RDL
"-" = indicates value is not available or does not apply
Lab-Dup = Laboratory QA/QC duplicate sample
Bold/shaded = exceeds FIGQG criteria

APPENDIX C

Data from Soil Vapour Probes

Table C.1 Results of Laboratory Analysis of Petroleum Hydrocarbons in Soil Vapour Ports
Canadian Coast Guard Southside Base, Berth 28, Southside Road, St. John's, NL
Stantec Project No. 121412715

	Soil Vapor VP1	Soil Vapor VP2	Soil Vapor VP3	Soil Vapor VP4
	ug/m^3			
Benzene	3.70	16	118	1590
Toluene	5.5	14.7	71	936
Ethylbenzene	1.6	13.3	59	2420
Xylene (Total)	5.2	67	207	8010
Aliphatic >C5-C6	12.7	14.4	577	29900
Aliphatic >C6-C8	50.2	60.2	4710	82300
Aliphatic >C8-C10	39	104	13800	62200
Aromatic >C7-C8 (TEX Excluded)	5	5	5	5
Aromatic >C8-C10	6.6	135	573	16400
Aliphatic >C10-C12	118	191	25100	33900
Aliphatic >C12-C16	156	200	5650	3500.0
Aromatic >C10-C12	8.4	287	2070	17600
Aromatic >C12-C16	5	42.7	1650	569

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Rootmat	- Vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Homogeneous	- same color and consistency throughout
Desiccated	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	- having cracks, and hence a blocky structure
Varved	- composed of regular alternating layers of silt and clay
Stratified	- composed of alternating successions of different soil types, e.g. silt and sand
Layer	- > 75 mm in thickness
Seam	- 2 mm to 75 mm in thickness
Parting	- < 2 mm in thickness

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488). The classification excludes particles larger than 76 mm (3 inches). The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):
Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test N-Value (also known as N-Index) in accordance with ASTM D1586. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kips/sq.ft.	kPa	
Very Soft	<0.25	<12.5	<2
Soft	0.25 - 0.5	12.5 - 25	2-4
Firm	0.5 - 1.0	25 - 50	4-8
Stiff	1.0 - 2.0	50 – 100	8-15
Very Stiff	2.0 - 4.0	100 - 200	15-30
Hard	>4.0	>200	>30

ROCK DESCRIPTION

Terminology describing rock quality:

RQD	Rock Mass Quality		
0-25	*Very Poor Quality*	*Very Severely Fractured*	*Crushed*
25-50	*Poor Quality*	*Severely Fractured*	*Shattered or Very Blocky*
50-75	*Fair Quality*	*Fractured*	*Blocky*
75-90	*Good Quality*	*Moderately Jointed*	*Sound*
90-100	*Excellent Quality*	*Intact*	*Very Sound*

The RQD denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD determined in accordance with ASTM D6032.

Terminology describing rock with respect to discontinuity spacing:

Spacing (mm)	Discontinuity	Bedding, Laminations, Bands
> 6000	*Extremely Wide*	-
2000-6000	*Very Wide*	*Very Thick*
600-2000	*Wide*	*Thick*
200-600	*Moderate*	*Medium*
60-200	*Close*	*Thin*
20-60	*Very Close*	*Very Thin*
<20	*Extremely Close*	*Laminated*
<6	-	*Thinly Laminated*

Terminology describing rock strength:

Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	< 1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	> 250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discolouration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discoloured.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

Solid Core Recovery (SCR):
Solid core recovery is defined as the cumulative length of all solid core in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis (i.e. length of core run excluding broken, crushed or rubble zones)

Fracture Index (FI):
Fracture Index is defined as the number of naturally occurring fractures occurring per given length of core. The Fracture Index is reported as a simple count of fractures.

STRATA PLOT

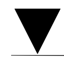
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.

Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Igneous Bedrock	Meta-morphic Bedrock	Sedi-mentary Bedrock

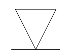
SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT



measured in standpipe, piezometer, or well



inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery (or total core recovery - TCR) is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (64 kg) hammer falling 30 inches (762 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. In accordance with ASTM D1586, the N-value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (152 to 457 mm). However, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (305 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-values cannot be presented, the total number of blows are reported over sampler penetration in millimeters (e.g., 50/75).

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to A size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (305 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

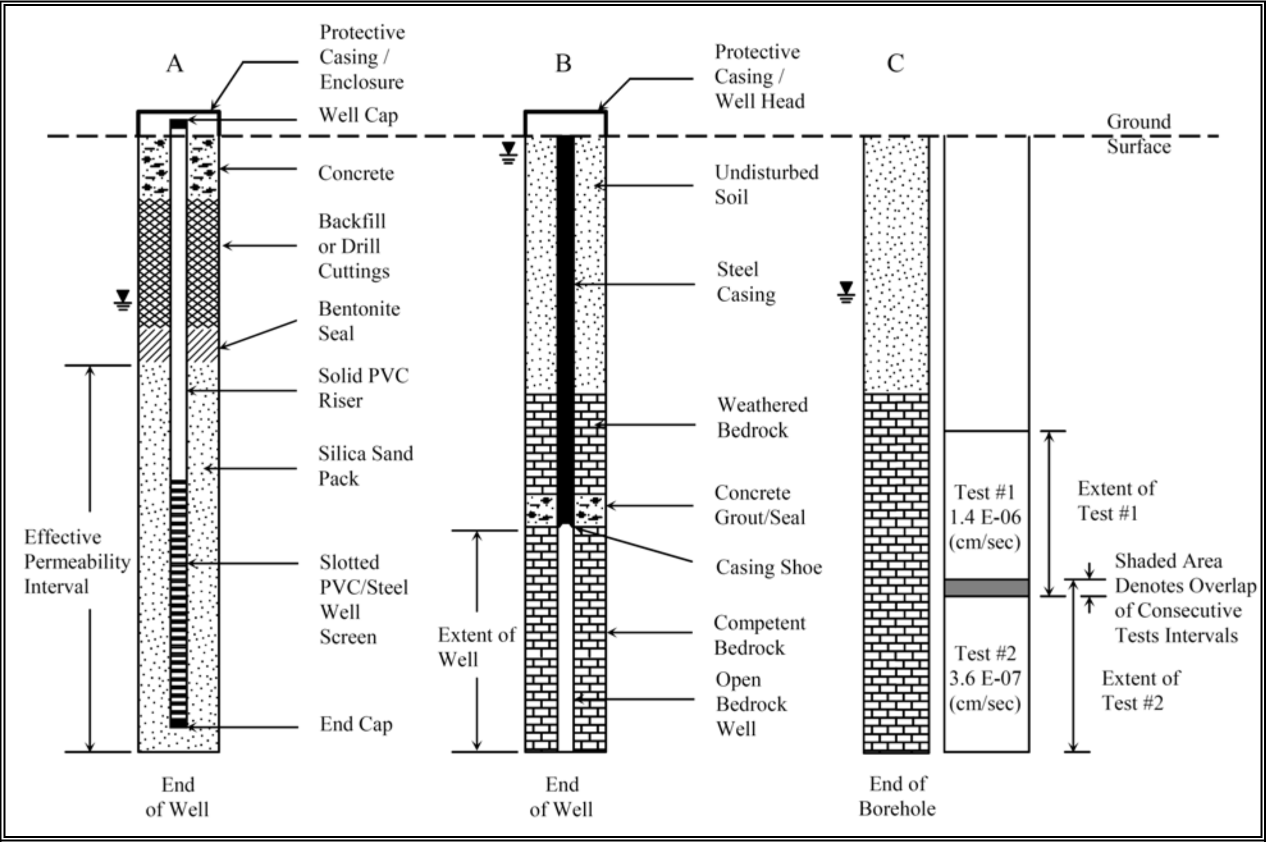
S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

SYMBOLS AND TERMS USED ON
MONITOR WELL, WATER WELL AND ENVIRONMENTAL RECORDS

Well Construction and Permeability Testing

Basic symbols used in typical monitor or water well and piezometer construction are shown below. The well construction symbols or materials shown below may be combined or altered to suit a particular application. The diagram shows: A) a typical piezometer or monitor well in overburden; B) a typical water well in bedrock; C) borehole permeability test results in bedrock.



Apparent Moisture Content

Terminology used to describe apparent moisture content at the time of borehole drilling or test pit excavation.

Symbol	Description
D	Dry – containing little or no moisture
M	Moist – containing some moisture without having ‘free’ moisture
S	Saturated – ‘free’ moisture can drain from material

Terminology Describing Contamination

Symbol	Description
PID	Photo Ionization Detector (readings in ppm)
TPH	Total Petroleum Hydrocarbon concentration (readings in ppm based on mass)
ppm	Parts Per Million (measurement of concentration, mg/kg or mg/L)
nd	Not Detected – below limit of quantification (LOQ)

Apparent Hydrocarbon Odour

Terminology used to describe apparent hydrocarbon odour at the time of borehole drilling or test pit excavation.

Value	Description
0	No apparent odour
1	Slight odour
2	Moderate odour
3	Strong odour

MONITOR WELL RECORD

Stantec

CLIENT	PWGSC
PROJECT	HHERA, Canadian Coast Guard, Berth 28, Southside Road
LOCATION	St. John's, NL
DATES (mm-dd-yy): BORING	7-10-13
WATER LEVEL	N/A
BOREHOLE No.	VP01
PAGE	1 of 1
PROJECT No.	121412715
DRILLING METHOD	Auger
SIZE	50mm
DATUM	N/A

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY (mm)	SAMPLES: N-VALUE OR RQD %	HYDROCARBON ODOUR	APPARENT MOISTURE CONTENT	PID (ppm)	TPH (ppm)	WELL CONSTRUCTION DETAILS
													FLUSH MOUNTED WELL HEAD ENCLOSURE
0		Asphalt											
		Silty SAND with gravel (SM): FILL											BENTONITE
													25 mm DIAMETER SCHEDULE 40 SOLID PVC RISER IN No. 2 SILICA SAND PACK
1													
													25 mm DIAMETER No. 10 SLOT PVC SCREEN IN No. 2 SILICA SAND PACK
													END CAP
		End of Borehole											
2													

Stantec

MONITOR WELL RECORD

BOREHOLE No. VP02
PAGE 1 of 1
CLIENT PWGSC
PROJECT No. 121412715
PROJECT HHERA, Canadian Coast Guard, Berth 28, Southside Road
DRILLING METHOD Auger
LOCATION St. John's, NL
SIZE 50mm
DATES (mm-dd-yy): BORING 7-10-13
WATER LEVEL N/A
DATUM N/A

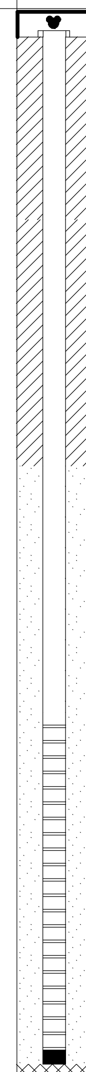
DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD %	HYDROCARBON ODOUR	APPARENT MOISTURE CONTENT	PID (ppm)	TPH (ppm)	WELL CONSTRUCTION DETAILS
													FLUSH MOUNTED WELL HEAD ENCLOSURE
0		Asphalt											
		Silty SAND with gravel (SM): FILL											BENTONITE
													25 mm DIAMETER SCHEDULE 40 SOLID PVC RISER IN No. 2 SILICA SAND PACK
1													
													25 mm DIAMETER No. 10 SLOT PVC SCREEN IN No. 2 SILICA SAND PACK
													END CAP
		End of Borehole											
2													

MONITOR WELL RECORD

Stantec

CLIENT	PWGSC
PROJECT	HHERA, Canadian Coast Guard, Berth 28, Southside Road
LOCATION	St. John's, NL
DATES (mm-dd-yy): BORING	7-10-13
WATER LEVEL	N/A
BOREHOLE No.	VP03
PAGE	1 of 1
PROJECT No.	121412715
DRILLING METHOD	Auger
SIZE	50mm
DATUM	N/A

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD %	HYDROCARBON ODOUR	APPARENT MOISTURE CONTENT	PID (ppm)	TPH (ppm)	WELL CONSTRUCTION DETAILS
													FLUSH MOUNTED WELL HEAD ENCLOSURE
0		Asphalt											
		Silty SAND with gravel (SM); some cobbles, trace boulders: FILL											BENTONITE; 25 mm DIAMETER SCHEDULE 40 SOLID PVC RISER IN No. 2 SILICA SAND PACK
1													25 mm DIAMETER No. 10 SLOT PVC SCREEN IN No. 2 SILICA SAND PACK; END CAP
		End of Borehole											
2													



Stantec

MONITOR WELL RECORD

BOREHOLE No. VP04
PAGE 1 of 1
CLIENT PWGSC
PROJECT HHERA, Canadian Coast Guard, Berth 28, Southside Road
LOCATION St. John's, NL
DATES (mm-dd-yy): BORING 7-10-13
WATER LEVEL N/A
PROJECT No. 121412715
DRILLING METHOD Auger
SIZE 50mm
DATUM N/A

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD %	HYDROCARBON ODOUR	APPARENT MOISTURE CONTENT	PID (ppm)	TPH (ppm)	WELL CONSTRUCTION DETAILS
													FLUSH MOUNTED WELL HEAD ENCLOSURE
0		Asphalt											
		Silty SAND with gravel (SM); some cobbles, trace boulders: FILL											BENTONITE
													25 mm DIAMETER SCHEDULE 40 SOLID PVC RISER IN No. 2 SILICA SAND PACK
1													
													25 mm DIAMETER No. 10 SLOT PVC SCREEN IN No. 2 SILICA SAND PACK
													END CAP
		End of Borehole											
2													

Success Through Science®

Your P.O. #: 16300R-20

Your Project #: 121412715
Site Location: CCG SOUTHSIDE BASE
Your C.O.C. #: 20002

Attention: Carolyn Anstey-Moore
Stantec Consulting Ltd
St. John's - Standing Offer
607 Torbay Rd
St. John's, NL
A1A 4Y6

Report Date: 2013/07/31

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B3B4536
Received: 2013/07/16, 10:37

Sample Matrix: AIR
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
BTEX and CCME Compounds in Air(TO-15mod)	2	N/A	2013/07/23	BRL SOP-00304	EPA TO-15mod
BTEX and CCME Compounds in Air(TO-15mod)	2	N/A	2013/07/24	BRL SOP-00304	EPA TO-15mod
BTEX Fractionation in Air (TO-15mod)	2	N/A	2013/07/23	BRL SOP-00304	EPA TO-15mod
BTEX Fractionation in Air (TO-15mod)	2	N/A	2013/07/24	BRL SOP-00304	EPA TO-15mod
Canister Pressure (TO-15)	2	N/A	2013/07/23	BRL SOP-00304	EPA TO-15
Canister Pressure (TO-15)	2	N/A	2013/07/24	BRL SOP-00304	EPA TO-15
Matrix Gases	4	N/A	2013/07/29	CAM SOP-00225, CAM SOP-00209	ASTM D1946-90

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Theresa Stephenson, Project Manager
Email: TStephenson@maxxam.ca
Phone# (905) 817-5763

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Total cover pages: 1

Maxxam Job #: B3B4536
Report Date: 2013/07/31

Stantec Consulting Ltd
Client Project #: 121412715
Site Location: CCG SOUTHSIDE BASE
Your P.O. #: 16300R-20
Sampler Initials: RP

RESULTS OF ANALYSES OF AIR

Maxxam ID		SG9102	SG9103		SG9104	SG9105	
Sampling Date		2013/07/12	2013/07/12		2013/07/12	2013/07/12	
COC Number		20002	20002		20002	20002	
	Units	**VP01 (SUMA #326)**	**VP02(SUMA #1030)**	**QC Batch**	**VP03(SUMA #235)**	**VP04(SUMA #2402)**	**QC Batch**
Volatile Organics							
Pressure on Receipt	psig	(-0.8)	(-2.2)	3290724	(-1.3)	(-1.1)	3291465

QC Batch = Quality Control Batch

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B3B4536
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Stantec Consulting Ltd
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COMPRESSED GAS PARAMETERS (AIR)

Maxxam ID		SG9102	SG9103	SG9104	SG9105		
Sampling Date		2013/07/12	2013/07/12	2013/07/12	2013/07/12		
COC Number		20002	20002	20002	20002		
	Units	**VP01 (SUMA #326)**	**VP02(SUMA #1030)**	**VP03(SUMA #235)**	**VP04(SUMA #2402)**	**RDL**	**QC Batch**
Fixed Gases							
Oxygen	% v/v	20.5	20.6	15.5	16.6	0.2	3296467
Methane	% v/v	ND	ND	ND	ND	0.2	3296467
Carbon Dioxide	% v/v	1.2	1.1	3.6	3.0	0.2	3296467

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: B3B4536
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Stantec Consulting Ltd
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Your P.O. #: 16300R-20
Sampler Initials: RP

VOLATILE ORGANIC HYDROCARBONS BY GC/MS (AIR)

Maxxam ID		SG9102	SG9103			SG9104		SG9105		
Sampling Date		2013/07/12	2013/07/12			2013/07/12		2013/07/12		
COC Number		20002	20002			20002		20002		
	Units	**VP01 (SUMA #326)**	**VP02(SUMA #1030)**	**RDL**	**QC Batch**	**VP03(SUMA #235)**	**RDL**	**VP04(SUMA #2402)**	**RDL**	**QC Batch**
Volatile Organics										
F1-BTEX, C6-C10 (as Toluene)	ug/m3	293	542	5.0	3290746	47400	38	365000	320	3291468
F2, C10-C16 (as Decane)	ug/m3	3360	2530	5.0	3290746	105000	38	98100	320	3291468
Benzene	ug/m3	3.7	16.0	1.2	3290746	118	9.1	1590	77	3291468
Toluene	ug/m3	5.5	14.7	1.6	3290746	71	12	936	100	3291468
Ethylbenzene	ug/m3	ND	13.3	1.6	3290746	59	12	2420	100	3291468
Total Xylenes	ug/m3	5.2	67.0	2.2	3290746	207	17	8010	140	3291468
Aliphatic >C5-C6	ug/m3	12.7	14.4	5.0	3290751	577	38	29900	320	3291471
Aliphatic >C6-C8	ug/m3	50.2	60.2	5.0	3290751	4710	38	82300	320	3291471
Aliphatic >C8-C10	ug/m3	39.0	104	5.0	3290751	13800	38	62200	320	3291471
Aliphatic >C10-C12	ug/m3	118	191	5.0	3290751	25100	38	33900	320	3291471
Aliphatic >C12-C16	ug/m3	156	200	5.0	3290751	5650	38	3500	320	3291471
Aromatic >C7-C8 (TEX Excluded)	ug/m3	ND	ND	5.0	3290751	ND	38	ND	320	3291471
Aromatic >C8-C10	ug/m3	6.6	135	5.0	3290751	573	38	16400	320	3291471
Aromatic >C10-C12	ug/m3	8.4	287	5.0	3290751	2070	38	17600	320	3291471
Aromatic >C12-C16	ug/m3	ND	42.7	5.0	3290751	1650	38	569	320	3291471
Surrogate Recovery (%)										
1,4-Difluorobenzene	%	88	104		3290746	94		94		3291468
Bromochloromethane	%	86	102		3290746	90		90		3291468
D5-Chlorobenzene	%	80	98		3290746	93		91		3291468

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam

Maxxam Job #: B3B4536
Report Date: 2013/07/31

Stantec Consulting Ltd
Client Project #: 121412715
Site Location: CCG SOUTHSIDE BASE
Your P.O. #: 16300R-20
Sampler Initials: RP

Test Summary

Maxxam ID SG9102
Sample ID VP01 (SUMA #326)
Matrix AIR

Collected 2013/07/12
Shipped
Received 2013/07/16

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
BTEX and CCME Compounds in Air(TO-15	GC/MS	3290746	N/A	2013/07/23	Jie Wu
BTEX Fractionation in Air (TO-15mod)	GC/MS	3290751	N/A	2013/07/23	Jie Wu
Canister Pressure (TO-15)	PRES	3290724	N/A	2013/07/23	Jie Wu
Matrix Gases	GC/TCD	3296467	N/A	2013/07/29	Tonghui (Jenny) Chen

Maxxam ID SG9103
Sample ID VP02(SUMA #1030)
Matrix AIR

Collected 2013/07/12
Shipped
Received 2013/07/16

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
BTEX and CCME Compounds in Air(TO-15	GC/MS	3290746	N/A	2013/07/23	Jie Wu
BTEX Fractionation in Air (TO-15mod)	GC/MS	3290751	N/A	2013/07/23	Jie Wu
Canister Pressure (TO-15)	PRES	3290724	N/A	2013/07/23	Jie Wu
Matrix Gases	GC/TCD	3296467	N/A	2013/07/29	Tonghui (Jenny) Chen

Maxxam ID SG9104
Sample ID VP03(SUMA #235)
Matrix AIR

Collected 2013/07/12
Shipped
Received 2013/07/16

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
BTEX and CCME Compounds in Air(TO-15	GC/MS	3291468	N/A	2013/07/24	Jie Wu
BTEX Fractionation in Air (TO-15mod)	GC/MS	3291471	N/A	2013/07/24	Jie Wu
Canister Pressure (TO-15)	PRES	3291465	N/A	2013/07/24	Jie Wu
Matrix Gases	GC/TCD	3296467	N/A	2013/07/29	Tonghui (Jenny) Chen

Maxxam ID SG9105
Sample ID VP04(SUMA #2402)
Matrix AIR

Collected 2013/07/12
Shipped
Received 2013/07/16

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
BTEX and CCME Compounds in Air(TO-15	GC/MS	3291468	N/A	2013/07/24	Jie Wu
BTEX Fractionation in Air (TO-15mod)	GC/MS	3291471	N/A	2013/07/24	Jie Wu
Canister Pressure (TO-15)	PRES	3291465	N/A	2013/07/24	Jie Wu
Matrix Gases	GC/TCD	3296467	N/A	2013/07/29	Tonghui (Jenny) Chen

Maxxam ID SG9105 Dup
Sample ID VP04(SUMA #2402)
Matrix AIR

Collected 2013/07/12
Shipped
Received 2013/07/16

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Matrix Gases	GC/TCD	3296467	N/A	2013/07/29	Tonghui (Jenny) Chen

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Maxxam Job #: B3B4536
Report Date: 2013/07/31

Stantec Consulting Ltd
Client Project #: 121412715
Site Location: CCG SOUTHSIDE BASE
Your P.O. #: 16300R-20
Sampler Initials: RP

GENERAL COMMENTS

Matrix Gas Analysis: Canisters were pressurized with Helium to enable sampling. Results and DLs adjusted accordingly.

Sample SG9104-01: A 7.6x dilution was prepared and analyzed. The DLs were adjusted accordingly.

Sample SG9105-01: Canister received at -1.1psig and was pressurized to 7.1psig, for a 1.6x pressure dilution.
A 40x dilution was prepared and analyzed, resulting in a 64x final dilution. The DLs were adjusted accordingly.

Results relate only to the items tested.

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Stantec Consulting Ltd
Attention: Carolyn Anstey-Moore
Client Project #: 121412715
P.O. #: 16300R-20
Site Location: CCG SOUTHSIDE BASE

Quality Assurance Report

Maxxam Job Number: GB3B4536

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	%Recovery	Units	QC Limits
3290746 JIW	Spiked Blank	1,4-Difluorobenzene	2013/07/23		100	%	60 - 140
		Bromochloromethane	2013/07/23		97	%	60 - 140
		D5-Chlorobenzene	2013/07/23		97	%	60 - 140
		Benzene	2013/07/23		106	%	70 - 130
		Toluene	2013/07/23		104	%	70 - 130
		Ethylbenzene	2013/07/23		107	%	70 - 130
		Total Xylenes	2013/07/23		105	%	70 - 130
	Method Blank	1,4-Difluorobenzene	2013/07/23		90	%	60 - 140
		Bromochloromethane	2013/07/23		89	%	60 - 140
		D5-Chlorobenzene	2013/07/23		84	%	60 - 140
		F1-BTEX, C6-C10 (as Toluene)	2013/07/23	ND, RDL=5.0		ug/m3	
		F2, C10-C16 (as Decane)	2013/07/23	ND, RDL=5.0		ug/m3	
		Benzene	2013/07/23	ND, RDL=1.2		ug/m3	
		Toluene	2013/07/23	ND, RDL=1.6		ug/m3	
		Ethylbenzene	2013/07/23	ND, RDL=1.6		ug/m3	
		Total Xylenes	2013/07/23	ND, RDL=2.2		ug/m3	
3290751 JIW	Method Blank	Aliphatic >C5-C6	2013/07/23	ND, RDL=5.0		ug/m3	
		Aliphatic >C6-C8	2013/07/23	ND, RDL=5.0		ug/m3	
		Aliphatic >C8-C10	2013/07/23	ND, RDL=5.0		ug/m3	
		Aliphatic >C10-C12	2013/07/23	ND, RDL=5.0		ug/m3	
		Aliphatic >C12-C16	2013/07/23	ND, RDL=5.0		ug/m3	
		Aromatic >C7-C8 (TEX Excluded)	2013/07/23	ND, RDL=5.0		ug/m3	
		Aromatic >C8-C10	2013/07/23	ND, RDL=5.0		ug/m3	
		Aromatic >C10-C12	2013/07/23	ND, RDL=5.0		ug/m3	
		Aromatic >C12-C16	2013/07/23	ND, RDL=5.0		ug/m3	
	RPD - Sample/Sample Dup	Aliphatic >C5-C6	2013/07/23	NC		%	25
		Aliphatic >C6-C8	2013/07/23	2.1		%	25
		Aliphatic >C8-C10	2013/07/23	3.6		%	25
		Aliphatic >C10-C12	2013/07/23	NC		%	25
		Aliphatic >C12-C16	2013/07/23	NC		%	25
		Aromatic >C7-C8 (TEX Excluded)	2013/07/23	NC		%	25
		Aromatic >C8-C10	2013/07/23	2.0		%	25
		Aromatic >C10-C12	2013/07/23	1.4		%	25
		Aromatic >C12-C16	2013/07/23	NC		%	15
3291468 JIW	Spiked Blank	1,4-Difluorobenzene	2013/07/24		103	%	60 - 140
		Bromochloromethane	2013/07/24		99	%	60 - 140
		D5-Chlorobenzene	2013/07/24		104	%	60 - 140
		Benzene	2013/07/24		108	%	70 - 130
		Toluene	2013/07/24		106	%	70 - 130
		Ethylbenzene	2013/07/24		105	%	70 - 130
		Total Xylenes	2013/07/24		105	%	70 - 130
	Method Blank	1,4-Difluorobenzene	2013/07/24		90	%	60 - 140
		Bromochloromethane	2013/07/24		86	%	60 - 140
		D5-Chlorobenzene	2013/07/24		80	%	60 - 140
		F1-BTEX, C6-C10 (as Toluene)	2013/07/24	ND, RDL=5.0		ug/m3	
		F2, C10-C16 (as Decane)	2013/07/24	ND, RDL=5.0		ug/m3	
		Benzene	2013/07/24	ND, RDL=1.2		ug/m3	
		Toluene	2013/07/24	ND, RDL=1.6		ug/m3	
		Ethylbenzene	2013/07/24	ND, RDL=1.6		ug/m3	
		Total Xylenes	2013/07/24	ND, RDL=2.2		ug/m3	
	RPD - Sample/Sample Dup	F1-BTEX, C6-C10 (as Toluene)	2013/07/24	6.4		%	25

Stantec Consulting Ltd
Attention: Carolyn Anstey-Moore
Client Project #: 121412715
P.O. #: 16300R-20
Site Location: CCG SOUTHSIDE BASE

Quality Assurance Report (Continued)

Maxxam Job Number: GB3B4536

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	%Recovery	Units	QC Limits
3291468 JIW	RPD - Sample/Sample Dup	F2, C10-C16 (as Decane)	2013/07/24	3.6		%	25
		Benzene	2013/07/24	5.6		%	25
		Toluene	2013/07/24	0.3		%	25
		Ethylbenzene	2013/07/24	NC		%	25
		Total Xylenes	2013/07/24	1.7		%	25
3291471 JIW	Method Blank	Aliphatic >C5-C6	2013/07/24	ND, RDL=5.0		ug/m3	
		Aliphatic >C6-C8	2013/07/24	ND, RDL=5.0		ug/m3	
		Aliphatic >C8-C10	2013/07/24	ND, RDL=5.0		ug/m3	
		Aliphatic >C10-C12	2013/07/24	ND, RDL=5.0		ug/m3	
		Aliphatic >C12-C16	2013/07/24	ND, RDL=5.0		ug/m3	
		Aromatic >C7-C8 (TEX Excluded)	2013/07/24	ND, RDL=5.0		ug/m3	
		Aromatic >C8-C10	2013/07/24	ND, RDL=5.0		ug/m3	
		Aromatic >C10-C12	2013/07/24	ND, RDL=5.0		ug/m3	
		Aromatic >C12-C16	2013/07/24	ND, RDL=5.0		ug/m3	
3296467 TJC	Method Blank	Oxygen	2013/07/29	ND, RDL=0.1		% v/v	
		Methane	2013/07/29	ND, RDL=0.1		% v/v	
		Carbon Dioxide	2013/07/29	ND, RDL=0.1		% v/v	
	RPD - Sample/Sample Dup	Oxygen	2013/07/29	0.2		%	20
		Methane	2013/07/29	NC		%	20
		Carbon Dioxide	2013/07/29	0.4		%	20

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

APPENDIX D

Human Health Risk Calculations

Indoor Air Estimate Based on Soil Vapour Data

Parameter	Soil Vapor				Toxicological Reference Value (TC or UR)	Target HQ/ILCR	Indoor Air Calculation from Soil Vapor			
	VP1	VP2	VP3	VP4			VP1	VP2	VP3	VP4
	ug/m^3						With a dilution factor of 50			
Benzene	3.70E+00	1.60E+01	1.18E+02	1.59E+03	3.30E-03	1.00E-05	6.69E-08	2.89E-07	2.13E-06	2.88E-05
Toluene	5.5	14.7	71	936	3.75	0.5	8.037E-06	2.148E-05	0.0001038	0.0013678
Ethylbenzene	1.6	13.3	59	2420	1	0.5	8.768E-06	7.288E-05	0.0003233	0.0132616
Xylenes	5.2	67	207	8010	0.18	0.5	0.0001583	0.0020398	0.006302	0.24386
Total PHC F1						0.5	0.0004818	0.0043596	0.0929673	0.8237006
PHC F1 – Aliphatic $>C_5$-C_6	12.7	14.4	577	29900	18.4	-	3.782E-06	4.289E-06	0.0001718	0.008905
PHC F1 – Aliphatic $>C_6$-C_8	50.2	60.2	4710	82300	18.4	-	1.495E-05	1.793E-05	0.0014028	0.0245111
PHC F1 – Aliphatic $>C_8$-C_{10}	39	104	13800	62200	1	-	0.0002137	0.0005699	0.075624	0.340856
PHC F1 – Aromatic $>C_7$-C_8 (TEX Excluded)	5	5	5	5	0.4	-	0.0000685	0.0000685	0.0000685	0.0000685
PHC F1 – Aromatic $>C_8$-C_{10}	6.6	135	573	16400	0.2	-	0.0001808	0.003699	0.0157002	0.44936
Total PHC F2						0.5	0.0018687	0.0111765	0.270438	0.7027826
PHC F2 – Aliphatic $>C_{10}$-C_{12}	118	191	25100	33900	1	-	0.0006466	0.0010467	0.137548	0.185772
PHC F2 – Aliphatic $>C_{12}$-C_{16}	156	200	5650	3500	1	-	0.0008549	0.001096	0.030962	0.01918
PHC F2 – Aromatic $> C_{10}$-C_{12}	8.4	287	2070	17600	0.2	-	0.0002302	0.0078638	0.056718	0.48224
PHC F2 – Aromatic $> C_{12}$-C_{16}	5	42.7	1650	569	0.2	-	0.000137	0.00117	0.04521	0.0155906

Site Specific Target Levels for Human Health (Non-carcinogenic Substances) - Construction Construction

Southside Base

Receptor: **Construction** **Construction**

$$\text{SSTL Construction} = \frac{\text{TDI x SAF x BW}}{(AF_{gut} \text{ x SIR x } ET_{ing}) + (AF_{lung} \text{ x } IR_{soil} \text{ x } ET_{inh}) + (AF_{skin} \text{ x SDR x } ET_{derm})} + \text{BSC}$$

$$\text{HQ Construction} = \frac{\text{Cs x } [(AF_{gut} \text{ x SIR x } ET_{ing}) + (AF_{lung} \text{ x } IR_{soil} \text{ x } ET_{inh}) + (AF_{skin} \text{ x SDR x } ET_{derm})]}{\text{TDI x BW}}$$

Compound	EPC (mg/kg)	TDI_o (mg/kg-day)	TDI_i (mg/kg-day)	SAF	BSC	AF_{gut}	AF_{lung}	AF_{skin}	Non-Carc. Oral Dose (mg/kg-d)	Non-Carc. Dermal Dose (mg/kg-d)	Non-Carc. Inhalation Dose (mg/kg-d)	Oral/ Dermal HQ (unitless)	Inhalation HQ (unitless)	HQ (unitless)	SSTL - Construction (mg/kg)
Lead	480	**0.00185**		0.2	0	0.6	1	0.006	2.91E-04	4.98E-05	7.07E-06	1.84E-01	3.82E-03	0.19	511

Time on site:		
Hours per day (inhalation)	10	(ingestion/dermal contact always assumed 24 hours per day)
Days per Week	5	
Weeks per Year	52	

Parameter	**Definition (units)**	**Default Value**	**Reference**
TDI =	reference dose (mg/kg bw-day)	chemical specific	Chemical specific (Bold = PQRA;)
C_S =	concentration in soil (mg/kg)	site specific	calculated Exposure Point Concentration (EPC)
SAF =	soil allocation factor (unitless)	chemical specific	
BW =	body weight (kg)	70.7	Health Canada (2010) - Construction
BSC =	background soil concentration (mg/kg)	chemical specific	Health Canada (2010) - Construction
AF_{gut} =	absorption factor for gut (unitless)	chemical specific	Assumed
AF_{lung} =	absorption factor for lung (unitless)	chemical specific	Assumed
AF_{skin} =	absorption factor skin (unitless)	chemical specific	Health Canada (2010)
SIR =	soil ingestion rate (kg/day)	0.0001	Health Canada (2010) - Construction
IR_{soil} =	soil inhalation rate (kg/day) = CRP (kg/m^3) x IR_{air} (m^3/day)	3.5E-06	calculated
SDR =	soil dermal contact rate (kg/day) = (SA_{hands} x M_{hands}) + (SA_{body} x M_{body}) x 1E-6 (kg/mg)	0.001712	calculated
ET_{ing} =	exposure term for soil ingestion pathway (unitless)	0.7143	Site Specific [24 Hours per Day, 5 Days per Week, 52 Weeks per Year]
ET_{inh} =	exposure term for soil inhalation pathway (unitless)	0.2976	Site Specific [10 Hours per Day, 5 Days per Week, 52 Weeks per Year]
ET_{derm} =	exposure term for soil dermal contact pathway (unitless)	0.7143	Site Specific [24 Hours per Day, 5 Days per Week, 52 Weeks per Year]
CRP =	concentration of respirable particles (kg/m^3)	2.50E-07	Health Canada (2010) - Unpaved roads with vehicle traffic
IR_{air} =	daily inhalation rate (m^3/day)	14	Health Canada (2010) - Construction
SA_{hands} =	skin surface area - hands (cm^2/day)	890	Health Canada (2010) - Construction
SA_{body} =	skin surface area - rest of body (cm^2/day)	8220	Health Canada (2010) - Construction - arms
M_{hands} =	soil to skin adherence factor - hands (mg/cm^2)	1	Health Canada (2010) - Construction
M_{body} =	soil to skin adherence factor - rest of body (mg/cm^2)	0.1	Health Canada (2010) - Construction
na =	not available		

Site-Specific Target Levels for Human Health (Non-Threshold Substances) - Construction Construction
Southside Base

Receptor: **Construction** **Construction**

$$\text{ILCR Construction} = \frac{C_s \times [(AF_{gut} \times SIR_{adj} \times ET_{ing} \times SF_o) + (AF_{lung} \times IR_{soil\ adj} \times ET_{inh} \times SF_i) + (AF_{skin} \times SDR_{adj} \times ET_{derm} \times SF_o)] \times YE}{BW * LE}$$

Compound	SF_o (mg/kg-d)$^{-1}$	SF_i (mg/kg-d)$^{-1}$	SF_{derm} (mg/kg-d)$^{-1}$	EPC (mg/kg)	AF_{gut}	AF_{lung}	AF_{skin}	Dose (oral) (mg/kg-d)	Dose (inhalation) (mg/kg-d)	Dose (dermal) (mg/kg-d)	ILCR (oral) (unitless)	ILCR (Inhalation) (unitless)	ILCR (dermal) (unitless)	ILCR (SUM - Soil) (unitless)
B(a)P TPE	2.3	0.13	N/A	12	1	1	0.148	1.52E-07	2.21E-09	3.84E-07	3.49E-07	2.87E-10	8.83E-07	1.23E-06

Time on site:		
Hours per day (inhalation)	10	
Days per Week	5	
Weeks per Year	52	
Years Exposed	1	Health Canada (2010)
Life Expectancy	80	Health Canada (2010)

Parameter	**Definition (units)**	Units	**Default Value**	**Reference**
SF_o =	oral slope factor	[1/(mg/kg-day)]	chemical specific	Health Canada (2010) BOLD = PQRA
SF_i =	inhalation slope factor	[1/(mg/kg-day)]	chemical specific	Health Canada (2010)
C_S =	concentration in soil	(mg/kg)	chemical specific	calculated Exposure Point Concentration (EPC)
BW =	body weight	(kg)	70.7	Health Canada (2010) - Construction
TR =	target risk	(unitless)	1.00E-05	Health Canada (2010)
BSC =	background soil concentration	(mg/kg)	chemical specific	
AF_{gut} =	absorption factor for gut	(unitless)	chemical specific	Assumed
AF_{lung} =	absorption factor for lung	(unitless)	chemical specific	Assumed
AF_{skin} =	absorption factor skin	(unitless)	chemical specific	Health Canada (2010)
SIR_{adj} =	soil ingestion rate	(kg soil/d)	1.00E-04	Health Canada (2010) - Construction
$IR_{soil\ adj}$ =	soil inhalation rate = CRP x IR_{air}	(m3 air/day)	3.50E-06	calculated
SDR_{adj} =	soil dermal contact rate = (SA_{hands} x M_{hands}) + (SA_{body} x M_{body}) x 10^{-6} (kg/mg)	(kg/event)	1.71E-03	calculated
ET_{ing} =	exposure term for soil ingestion pathway	(unitless)	0.714	Site Specific [24 Hours per Day, 5 Days per Week, 52 Weeks per Year]
ET_{inh} =	exposure term for soil inhalation pathway	(unitless)	0.298	Site Specific [10 Hours per Day, 5 Days per Week, 52 Weeks per Year]
ET_{derm} =	exposure term for soil dermal contact pathway	(unitless)	0.714	Site Specific [24 Hours per Day, 5 Days per Week, 52 Weeks per Year]
YE =	years exposed	(years)	1	Health Canada (2010)
CRP =	concentration of respirable particles	(kg/m3)	2.50E-07	Health Canada (2010) - Unpaved roads with vehicle traffic
$IR_{air\ adj}$ =	daily inhalation rate	(m3 air/day)	14.0	Health Canada (2010) - Construction
$SA_{hands\ adj}$ =	skin surface area - hands	(cm2)	890	Health Canada (2010) - Construction
$SA_{body\ adj}$ =	skin surface area - arms and legs	(cm2)	8220	Health Canada (2010) - Construction
M_{hands} =	soil to skin adherence factor - hands	(mg/cm2/event)	1	Health Canada (2010) - Construction
M_{body} =	soil to skin adherence factor - rest of body	(mg/cm2/event)	0.1	Health Canada (2010) - Construction

Input Parameters for Inhalation Soil and Groundwater Quality Guidelines

Southside Base, Berth 28
St. John's, NL

Soil Parameters	**Unit**	**Coarse Soil**
Soil Bulk Density, ρ_B	g/cm^3	1.7
Soil Total Porosity, θ_t	unitless	0.36
Soil Moisture-Filled Porosity, θ_w	unitless	0.119
Soil Vapour-Filled Porosity, θ_a	unitless	0.241
Soil Organic Carbon Fraction, f_{oc}	unitless	0.005
Soil Vapour Permeability, k_v	cm^2	5.0E-08

Building Parameters	**Unit**	**Commerical Slab-on-Grade**
Building Length, L_B	cm	5,500
Building Width, W_B	cm	3,250
Building Height, H_B	cm	300
Area of Building Substructure, A_B	cm^2	1.8E+07
Thickness of Floor Slab, L_{crack}	cm	11.25
Depth of Floor Slab Below Ground, Z_{crack}	cm	11.25
Distance from Source to Slab, L_T	cm	30
Area of Cracks, A_{crack}	cm^2	1.1E+04
Length of Crack (floor-wall seam), X_{crack}	cm	17500
Air Exchange Rate, ACH	1/h	0.9
Pressure Differential, ΔP	$g/cm*s^2$	20

Human Receptor Characteristics	**Unit**	**Commercial**
Exposure Term	unitless	0.2381
TargetCancer Risk	unitless	1.0E-05

Calculated Parameters	**Unit**	
Radius of Idealized Cylinder, r_{crack}	cm	0.633
Flow Rate into Building, Q_{soil}	cm^3/s	171.094
Building Ventilation Rate, Q_B	cm^3/s	1.34E+06

"Hidden Parameters"	**Unit**	
Viscosity of air, μ_{air}	g/cm*s	0.000180

Chemical Parameters and Tier 2 Soil and Groundwater Quality Guidelines for Inhalation
Southside Base, Berth 28
St. John's, NL

		BTEX				F1			F2				
Chemical Parameters	**Units**	**Benzene**	**Toluene**	**Ethyl benzene**	**Xylenes**	**Aliphatic C_6-C_8**	**Aliphatic C_8-C_{10}**	**Aromatic C_8-C_{10}**	**Aliphatic C_{10}-C_{12}**	**Aliphatic C_{12}-C_{16}**	**Aromatic C_{10}-C_{12}**	**Aromatic C_{12}-C_{16}**	**Naphthalene**
Physical/Chemical Properties													
Organic Carbon Partition Coefficient, K_{oc}	ml/g	81	234	537	586	3981	31623	1585	251189	5010000	2512	5012	1837
Diffusivity in Air, D_a	cm^2/s	8.80E-02	8.70E-02	7.50E-02	7.80E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.90E-02
Solubility, S	mg/L	1,780	515	152	198	5.4	0.43	65	0.034	0.00076	25	5.8	31
Henry's Law Constant, H'	unitless	0.225	0.274	0.358	0.252	50	80	0.48	120	520	0.14	0.053	0.018
Toxicological Properties													
Unit Risk Factor, URF	$(mg/m^3)^{-1}$	0.0033	-	-	-	-	-	-	-	-	-	-	-
Tolerable Concentration, TC	mg/m^3	-	3.8	1	0.18	18.4	1	0.2	1	1	0.2	0.2	0.0037
Background Concentrations, C_a	mg/m^3	-	0.0442	0.0075	0.00182	0.0911	0.0388	0.0375	0	0	0	0	0
Background Soil Concentration, BSC	mg/kg	0	0	0	0	0	0	0	0	0	0	0	0
Soil Allocation Factor, SAF	unitless	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.2
Adjustment Factor, AF	unitless	10	10	10	10	10	10	10	10	10	10	10	10
Calculated Parameters - CWS													
Effective Soil Diffusion Coeff, D^{eff}_T	cm^2/s	5.91E-03	5.85E-03	5.04E-03	5.24E-03	3.36E-03	3.36E-03	3.36E-03	3.36E-03	3.36E-03	3.36E-03	3.36E-03	3.97E-03
Effective Crack Diffusion Coeff, D_{crack}	cm^2/s	2.25E-02	2.23E-02	1.92E-02	2.00E-02	1.28E-02	1.28E-02	1.28E-02	1.28E-02	1.28E-02	1.28E-02	1.28E-02	1.51E-02
Term 1: $(D^{eff}_T*A_B)/(Q_B*L_T)$	unitless	2.63E-03	2.60E-03	2.24E-03	2.33E-03	1.49E-03	1.49E-03	1.49E-03	1.49E-03	1.49E-03	1.49E-03	1.49E-03	1.76E-03
Term 2: $(Q_{soil}*L_{crack})/(D_{crack}*A_{crack})$	unitless	7.71E+00	7.80E+00	9.04E+00	8.69E+00	1.36E+01	1.36E+01	1.36E+01	1.36E+01	1.36E+01	1.36E+01	1.36E+01	1.15E+01
Term 3: $(D^{eff}_T*A_B)/(Q_{soil}*L_T)$	unitless	2.06E+01	2.04E+01	1.76E+01	1.83E+01	1.17E+01	1.17E+01	1.17E+01	1.17E+01	1.17E+01	1.17E+01	1.17E+01	1.38E+01
Term 4: EXP(Term 2)	unitless	2.22E+03	2.43E+03	8.45E+03	5.97E+03	7.77E+05	7.77E+05	7.77E+05	7.77E+05	7.77E+05	7.77E+05	7.77E+05	9.82E+04
Attenuation Factor, α	unitless	1.22E-04	1.22E-04	1.21E-04	1.21E-04	1.18E-04	1.18E-04	1.18E-04	1.18E-04	1.18E-04	1.18E-04	1.18E-04	1.19E-04
Dilution Factor, DF	unitless	8.21E+03	8.22E+03	8.28E+03	8.26E+03	8.51E+03	8.51E+03	8.51E+03	8.51E+03	8.51E+03	8.51E+03	8.51E+03	8.40E+03
Residual Saturation, Csat	mg/kg	902	659	426	601	146	73	524	43	19	316	146	287
Soil Guideline, SRG_i	mg/kg	2.35	3020	1350	372	1770	364	488	1895	8629	3228	16942	134.31
PHC Mass Fractions, MFi	unitless	-	-	-	-	0.26	0.67	0.06	0.24	0.53	0.07	0.16	-
Soil Guideline for PHC (CWS - no Csat)	mg/kg					F1 =	474		F2 =	4560			
Site Maximum Concentration (mg/kg)		0.83	0.29	1.8	4	364	938	84	5760	12720	1680	3840	38
HQ (or ILCR for benzene) estimated as max concentration x SAF (or target ILCR)/SRG		3.53191E-06	4.8013E-05	0.00066667	0.00537634	0.10282739	1.28920418	0.08614843	1.52000706	0.7370293	0.26025642	0.11332721	0.0565855

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	Sheet2.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

TPE

General Statistics

Number of Valid Observations	24	Number of Distinct Observations	23

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.0252	Minimum of Log Data	-3.681
Maximum	24.08	Maximum of Log Data	3.181
Mean	3.254	Mean of log Data	-0.848
Geometric Mean	0.428	SD of log Data	2.244
Median	0.501		
SD	6.834		
Std. Error of Mean	1.395		
Coefficient of Variation	2.1		
Skewness	2.657		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.52	Shapiro Wilk Test Statistic	0.926
Shapiro Wilk Critical Value	0.916	Shapiro Wilk Critical Value	0.916
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	5.645	95% H-UCL	43.7
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	14.18
95% Adjusted-CLT UCL (Chen-1995)	6.357	97.5% Chebyshev (MVUE) UCL	18.61
95% Modified-t UCL (Johnson-1978)	5.771	99% Chebyshev (MVUE) UCL	27.3
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.32	Data appear Lognormal at 5% Significance Level	
Theta Star	10.16		
MLE of Mean	3.254		
MLE of Standard Deviation	5.751		
nu star	15.37		
Approximate Chi Square Value (.05)	7.517	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0392	95% CLT UCL	5.549
Adjusted Chi Square Value	7.133	95% Jackknife UCL	5.645
		95% Standard Bootstrap UCL	5.538
Anderson-Darling Test Statistic	1.192	95% Bootstrap-t UCL	10.13
Anderson-Darling 5% Critical Value	0.844	95% Hall's Bootstrap UCL	11.48
Kolmogorov-Smirnov Test Statistic	0.194	95% Percentile Bootstrap UCL	5.677
Kolmogorov-Smirnov 5% Critical Value	0.192	95% BCA Bootstrap UCL	6.501
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	9.335
		97.5% Chebyshev(Mean, Sd) UCL	11.97
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	17.13
95% Approximate Gamma UCL (Use when n >= 40)	6.652		
95% Adjusted Gamma UCL (Use when n < 40)	7.01		
Potential UCL to Use		Use 97.5% Chebyshev (Mean, Sd) UCL	11.97

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	Sheet1.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

AS

General Statistics

Number of Valid Observations	23	Number of Distinct Observations	21

Raw Statistics

Minimum	2.9
Maximum	46
Mean	9.839
Geometric Mean	7.456
Median	6.8
SD	9.388
Std. Error of Mean	1.958
Coefficient of Variation	0.954
Skewness	2.849

Log-transformed Statistics

Minimum of Log Data	1.065
Maximum of Log Data	3.829
Mean of log Data	2.009
SD of log Data	0.708

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.678
Shapiro Wilk Critical Value	0.914

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.94
Shapiro Wilk Critical Value	0.914

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	13.2
95% UCLs (Adjusted for Skewness)	
95% Adjusted-CLT UCL (Chen-1995)	14.3
95% Modified-t UCL (Johnson-1978)	13.39

Assuming Lognormal Distribution

95% H-UCL	13.31
95% Chebyshev (MVUE) UCL	15.99
97.5% Chebyshev (MVUE) UCL	18.82
99% Chebyshev (MVUE) UCL	24.38

Gamma Distribution Test

k star (bias corrected)	1.727
Theta Star	5.697
MLE of Mean	9.839
MLE of Standard Deviation	7.487
nu star	79.45
Approximate Chi Square Value (.05)	59.91
Adjusted Level of Significance	0.0389
Adjusted Chi Square Value	58.68
Anderson-Darling Test Statistic	0.838
Anderson-Darling 5% Critical Value	0.755
Kolmogorov-Smirnov Test Statistic	0.181
Kolmogorov-Smirnov 5% Critical Value	0.184

Data follow Appr. Gamma Distribution at 5% Significance Level

Data Distribution

Data Follow Appr. Gamma Distribution at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL (Use when n >= 40)	13.05
95% Adjusted Gamma UCL (Use when n < 40)	13.32

Nonparametric Statistics

95% CLT UCL	13.06
95% Jackknife UCL	13.2
95% Standard Bootstrap UCL	12.97
95% Bootstrap-t UCL	16
95% Hall's Bootstrap UCL	26.59
95% Percentile Bootstrap UCL	13.21
95% BCA Bootstrap UCL	14.28
95% Chebyshev(Mean, Sd) UCL	18.37
97.5% Chebyshev(Mean, Sd) UCL	22.06
99% Chebyshev(Mean, Sd) UCL	29.32

Potential UCL to Use

Use 95% Approximate Gamma UCL	13.05

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	Sheet1.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Aluminum

General Statistics

Number of Valid Observations	23	Number of Distinct Observations	14

Raw Statistics		**Log-transformed Statistics**	
Minimum	6100	Minimum of Log Data	8.716
Maximum	17000	Maximum of Log Data	9.741
Mean	11791	Mean of log Data	9.339
Geometric Mean	11368	SD of log Data	0.284
Median	11000		
SD	3111		
Std. Error of Mean	648.8		
Coefficient of Variation	0.264		
Skewness	-0.0923		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.964	Shapiro Wilk Test Statistic	0.944
Shapiro Wilk Critical Value	0.914	Shapiro Wilk Critical Value	0.914
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	12905	95% H-UCL	13212
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	14911
95% Adjusted-CLT UCL (Chen-1995)	12845	97.5% Chebyshev (MVUE) UCL	16251
95% Modified-t UCL (Johnson-1978)	12903	99% Chebyshev (MVUE) UCL	18882
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	12.05	Data appear Normal at 5% Significance Level	
Theta Star	978.1		
MLE of Mean	11791		
MLE of Standard Deviation	3396		
nu star	554.5		
Approximate Chi Square Value (.05)	500.9	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0389	95% CLT UCL	12858
Adjusted Chi Square Value	497.2	95% Jackknife UCL	12905
		95% Standard Bootstrap UCL	12862
Anderson-Darling Test Statistic	0.365	95% Bootstrap-t UCL	12917
Anderson-Darling 5% Critical Value	0.743	95% Hall's Bootstrap UCL	12817
Kolmogorov-Smirnov Test Statistic	0.13	95% Percentile Bootstrap UCL	12830
Kolmogorov-Smirnov 5% Critical Value	0.181	95% BCA Bootstrap UCL	12852
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	14619
		97.5% Chebyshev(Mean, Sd) UCL	15843
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	18247
95% Approximate Gamma UCL (Use when n >= 40)	13053		
95% Adjusted Gamma UCL (Use when n < 40)	13150		
Potential UCL to Use		Use 95% Student's-t UCL	12905

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Note: For highly negative-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

Lead

General Statistics

Number of Valid Observations	23	Number of Distinct Observations	20

Raw Statistics		Log-transformed Statistics	
Minimum	11	Minimum of Log Data	2.398
Maximum	2700	Maximum of Log Data	7.901
Mean	269.6	Mean of log Data	4.393
Geometric Mean	80.92	SD of log Data	1.605
Median	160		
SD	563.5		
Std. Error of Mean	117.5		
Coefficient of Variation	2.09		
Skewness	4.001		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.462	Shapiro Wilk Test Statistic	0.9
Shapiro Wilk Critical Value	0.914	Shapiro Wilk Critical Value	0.914
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	471.4	95% H-UCL	944.1
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	735.2
95% Adjusted-CLT UCL (Chen-1995)	567.6	97.5% Chebyshev (MVUE) UCL	939.7
95% Modified-t UCL (Johnson-1978)	487.7	99% Chebyshev (MVUE) UCL	1342

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	0.485	Data Follow Appr. Gamma Distribution at 5% Significance Level	
Theta Star	556.3		
MLE of Mean	269.6		
MLE of Standard Deviation	387.3		
nu star	22.29		
Approximate Chi Square Value (.05)	12.56	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0389	95% CLT UCL	462.9
Adjusted Chi Square Value	12.03	95% Jackknife UCL	471.4
		95% Standard Bootstrap UCL	464.4
Anderson-Darling Test Statistic	1.209	95% Bootstrap-t UCL	987.1
Anderson-Darling 5% Critical Value	0.803	95% Hall's Bootstrap UCL	1281
Kolmogorov-Smirnov Test Statistic	0.183	95% Percentile Bootstrap UCL	497.2
Kolmogorov-Smirnov 5% Critical Value	0.192	95% BCA Bootstrap UCL	594.5
Data follow Appr. Gamma Distribution at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	781.7
		97.5% Chebyshev(Mean, Sd) UCL	1003
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	1439
95% Approximate Gamma UCL (Use when n >= 40)	478.6		
95% Adjusted Gamma UCL (Use when n < 40)	499.7		

Potential UCL to Use		Use 95% Approximate Gamma UCL	478.6

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.