Remedial Options for PCB-Impacted Sediments, Hopedale, Labrador

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Executive Summary

Aivek-Stantec Limited Partnership (Stantec) was retained by the Newfoundland and Labrador Department of Environment and Conservation (NLDEC) to conduct a Remedial Options Study for Old Dump Pond and Hopedale Harbour in Hopedale, Newfoundland and Labrador (NL). The study was carried out as part of a larger remediation effort to address soil and sediment impacts associated with the Former United States Military Base and Residential Subdivision in Hopedale, NL. Sediment studies confirmed that elevated polychlorinated biphenyl (PCB) concentrations were present in Old Dump Pond sediment and the marine sediment and biota in Hopedale Harbour. Remedial methods and options for PCB impacted sediments were identified and evaluated following a five-step framework.

Old Dump Pond

Old Dump Pond was found to contain PCBs in sediment with higher concentrations found in areas coincident with metal and other submerged debris. As part of this study, Stantec determined a risk based site specific target level (SSTL) for sediment in Old Dump Pond to protect swimmers from ingestion of suspended sediments or dermal contact with bottom sediments while wading ($SSTL_{HH}$ = 770 mg/kg). Because none of the measured sediment PCB concentrations exceed the SSTL, there are no significant risks anticipated to recreational swimmers. Further, residents noted that the pond was not used for recreational fishing and past studies have determined there are only small fish species (e.g., stickleback) present in the pond. Thus, there is no expected fish consumption risk to the community from remnant PCB sediment concentrations.

Based on an ecological risk assessment conducted by Stantec (2010), no adverse ecological effects are expected to fish or fish eating birds (based on PCB concentrations in fish).

Because the concentrations of PCBs in sediment from Old Dump Pond are not expected to pose unacceptable risks to human or ecological receptors, no remediation is required.

There is a significant amount of metal and other debris in Old Dump Pond. There is also a small band of soil with PCB concentrations exceeding the terrestrial SSTL of 9 mg/kg located along the northeast shoreline at the end of the access road. This band of impacted soil requires removal and disposal at an off-site facility. When terrestrial soil remediation occurs here, NLDEC may elect to remove the physical hazards from Old Dump Pond to minimize physical hazard risks to human receptors. Although not required from a human health and ecological risk perspective, NLDEC may also elect to remove all or a portion of PCB impacted sediment from Old Dump Pond. This would only be considered if the remedial objective is to decrease local sediment PCB mass in Old Dump Pond.

Remedial options presented in this report for Old Dump Pond are based on removal of physical hazards and sediment from the pond, although as discussed, remediation is not necessary from an ecological or human health risk perspective.

For sediment, two remedial approaches were considered for Old Dump Pond, including "no further action", and removal. No further action was technically applicable as there is no human or ecological risk associated with residual sediments; however, a restriction on swimming would be necessary to protect them from physical hazards of debris. The second method was removal, either "in dry" or "in wet". Given the relatively shallow depth of the pond, the 'in-dry" approach was recommended as it allowed for visual confirmation of debris and removal of some of the underlying impacted sediments. Additionally, removal of soil along the southeast shoreline using conventional excavators once the pond is dewatered is also recommended.

<u>Hopedale Harbour</u>

Representatives of the community of Hopedale have expressed a desire to remediate the harbour sediments so that fish caught in the harbour can be consumed without restriction. However, this would require the residual sediment concentrations to be below 0.06 mg/kg thereby limiting PCB accumulations in fish tissue to exceed the consumption guideline. Although the study evaluated three potential remedial methods ("no further action", cap, or removal), none are expected to result in residual PCB concentrations in sediment below 0.06 mg/kg. This conclusion is based on information publically available from the United States on post-remedial monitoring of underwater marine caps and marine dredging projects. In the case of caps placed over very fine sediment, there is a potential for re-contamination due to resuspension and settling (during placement) and bioturbation (worms and small marine organisms moving through the cap and underlying sediment causing PCBs to mix into the cap). The use of a geosynthetic liner (and covered with sand/gravel) placed immediately over the proposed capping area would reduce the resuspension somewhat, but may be difficult to place due to currents and depths. Creating a local source of sand and aggregate for a capping project would also be challenging, given the quantities required. Capping could be applied to cover some of the higher concentration areas; however, it would not result in removing the fishing restriction from the harbour.

Dredging has been found to be effective in reducing the overall contaminant mass; however, it is also prone to resuspension settling and accuracy limitations, resulting in remnant concentrations at the sediment surface sometimes equal to the initial PCB concentrations, and seldom less than 0.5 to 1 mg/kg (for initial impact areas above 0.5 mg/kg). As such, no active remediation is recommended at this time until a more obtainable remedial objective, such as reducing the contaminant mass (i.e., focusing on the 1 mg/kg "hotspot") can be determined. Once a more obtainable remedial objective is determined, a target remediation zone can be identified. Costing should then be refined through discussions with specialty marine contractors.

The mobility of harbour sediments is limited if left as is based on the outcomes of a recent sediment transport study by Stantec. As such, there is no predicted long-term risk increase to the coastal areas due to migration of PCB impacted sediment and there will be no long-term requirements to restrict fishing beyond the harbour.

Preliminary calculations of residual PCB fish tissue concentrations using alternative sediment remedial targets indicate that some limited consumption of fish, including cod fillets, could occur if remediation focused on a hotspot (>0.35mg/kg) adjacent to the wharf area. In such a scenario, local residents could eat fish meat several times per month and still remain within the MOE consumption guidelines. However, an advisory against eating fish liver or other fatty organs would remain for the Harbor. If any remediation of Hopedale Harbour is considered, it should focus on the select high concentration areas that, once removed/capped might permit some fishing and consumption of fish from the harbour. However, as stated above, these efforts would not result in removing all restrictions on consumption of fish from the harbor as residual PCB concentrations in the upper sediments would most likely remain above 0.06 mg/kg, and fatty tissues such as liver and roe would continue to accumulate PCBs to levels unsuitable for human consumption.

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1.0 INTRODUCTION AND METHODS

Aivek-Stantec Limited Partnership (Stantec) was retained by the Newfoundland and Labrador Department of Environment and Conservation (NLDEC) to conduct a Remedial Options Study for Old Dump Pond and Hopedale Harbour in Hopedale, Newfoundland and Labrador (NL) (see Drawing No. 121411777.610-EE-01 in Appendix A). The study was carried out as part of the Implementation of Remedial Action Plan for the Former United States Military Base and Residential Subdivision in Hopedale, NL. The study was carried out following the completion of a Phase II/III Environmental Site Assessment (ESA), Human Health and Ecological Risk Assessment (HHERA) and Remedial Action Plan / Risk Management Plan (RAP/RMP) for the Former U.S. Military Site and Residential Subdivision (Stantec Report No. 121410103, dated May 17, 2010) and a subsequent three year marine sampling program conducted by Stantec between 2011 and 2013. Previous investigations have confirmed that elevated polychlorinated biphenyl (PCB) concentrations are present in sediment from Old Dump Pond and Hopedale Harbour.

The following report identifies and describes remedial options for sediments along with a framework for selection and implementation following a five-step process as follows:

- Step 1 - Establish Site Conditions
- Step 2 - Establish Remedial Objectives - Considering Management of Ecological and Human Health Risks, and Technological Limitations
- Step 3 - Identification of Viable Remedial Technologies and Management Options
- Step 4 - Screening of Remedial Options and Techniques
- Step 5 - Detailed Evaluation of Options and Costs

2.0 REGULATORY CONSIDERATIONS AND SITE-SPECIFIC TARGET LEVELS

NLDEC Policy Directive PPD05-01 allows a site owner to use either of two approaches when remediating chemical impacts on a site. Remediation of chemical impacts in various site media (e.g., soil, sediment, groundwater, surface water) can be completed using a criteria-based approach or a risk-based approach. Under the criteria-based remedial approach, the defined site impacts are remediated to levels below existing regulatory guidelines for the appropriate media. Under the risk-based remedial approach, the defined site impacts are remediated to levels below site-specific target levels (SSTLs) that are developed for the site during a site-specific human health risk assessment (HHRA) and ecological risk assessment (ERA) (if necessary).

For simple sites and sites with limited impacts, a criteria-based approach to remediation is often applied to guide the extent of removal of impacted media from the site. For more complex sites and sites with extensive impacts from multiple chemicals of concern (COCs), a human health and/or ecological risk assessment is often completed, based on the actual site conditions and the actual human and ecological usage of the site, to derive SSTLs to determine remedial options or a risk management strategy for the site. Stantec conducted a Human Health and Ecological Risk Assessment for the Former U.S. Military Site and Residential Subdivision in Hopedale in 2010 (report titled *Phase II/III Environmental Site Assessment, Human Health and Ecological Risk Assessments and Remedial Action / Risk Management Plan for the Former U.S. Military Site and Residential Subdivision at Hopedale, Labrador*. Stantec Project No. 121410103, final report dated May 17, 2010).

The regulatory guidelines and risk-based criteria that are considered appropriate for freshwater and marine sediment in Hopedale are described below.

2.1 Federal PCB Regulations

Environment Canada regulates the manufacture, sale, export, import, use, handling, storage, transport, labelling and destruction of PCBs in Canada under the Federal *PCB Regulations* (*Canada Environmental Protection Act*, 1999). Under the PCB Regulations, solids containing PCBs in a concentration of 50 mg/kg or more are classified as “PCB wastes” and must comply with requirements specified under the *Act*. As such, any sediment removed with PCB concentrations over 50 mg/kg would be subject to the requirements of the Regulations.

2.2 Site-Specific Target Levels

Terrestrial SSTLs

As part of the Human Health and Ecological Risk Assessment conducted by Stantec in 2010, SSTLs were calculated for COCs on-land, including PCBs. SSTLs were derived in accordance with the methods presented in *A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines* (CCME, 2006). The specific methods employed to develop the SSTLs were consistent with CCME and Health Canada protocols, and with standard human health risk assessment methodologies. An SSTL of 9 mg/kg was generated for PCBs in soil at residential areas of the site where residents of Hopedale would be expected to spend the majority of their time. An SSTL of 22 mg/kg was generated for PCBs in soil at the Former Radar Site where residents of Hopedale would be expected to visit areas occasionally for recreational purposes (*e.g.*, berry picking, hunting, and walking). Following consultation with the Inuit Community Government of Hopedale (ICGH) based on their potential future plans for residential expansion in certain areas of the Former Radar Site, as well as their concerns with maintaining traditional use of the land around the Former Radar Site, it was determined that all areas would be remediated to the residential SSTL of 9 mg/kg.

These values derived for the terrestrial environment are relevant in the context of how recovered sediments might be disposed of on land. For example, small quantities of sediment might be placed in the local landfill if concentrations are below the terrestrial SSTL of 9 mg/kg and the landfill operators are willing to accept the material. Consistent with previous soil remediation practices within the community limits, recovered sediment with concentrations of PCBs above the terrestrial SSTL of 9 mg/kg would be disposed of off-site.

Old Dump Pond

Human Health

Fishing was conducted at Old Dump Pond as part of previous investigations. With the exception of sticklebacks (*Gasterosteus aculeatus*), no other fish were collected from the pond. It was therefore concluded that no fish species that would be expected to be consumed by human receptors are present in Old Dump Pond. Fish consumption was not considered to be a relevant exposure pathway for Old Dump Pond and was therefore not included in the derivation of an SSTL.

Local residents have reported to Stantec that they do not swim in Old Dump Pond. This may be due to the presence of physical hazards (e.g., debris) in the pond. For completeness, however, Stantec has developed SSTLs for human receptors exposed to sediment through swimming as a potential exposure pathway in the event that the physical hazards are removed. For this exposure scenario, it was assumed that human receptors would be exposed to sediments via ingestion of suspended sediments while swimming (in conjunction with ingestion of surface water) and via dermal exposure to feet while wading.

The SSTL was derived as per CCME (1996) guidance that is by back-calculating a sediment concentration that would not exceed the target hazard quotient (HQ) of 0.2 or the incremental lifetime cancer risk (ILCR) of 1E-05. Background concentrations were assumed to be zero. SSTLs were calculated based on both carcinogenic and non-carcinogenic effects of PCBs with the lowest value selected as the SSTL for the site. Because toddlers are the most sensitive receptor for non-carcinogenic COCs, a toddler was selected to develop an SSTL based on non-carcinogenic effects. A life stage-integrated lifetime receptor was selected to develop an SSTL for carcinogenic effects.

Exposure durations were conservatively assumed to be 2 hours/day, 7 days/week, for 13 weeks/year. Thirteen weeks per year, during summer, was considered the maximum duration when water temperature would be conducive to swimming or wading. Applicable receptor characteristics were obtained from Health Canada (2010a) and are shown in Table 2.1. The tolerable daily intake (TDI) (0.00013 mg/kg/day) and absorption factors (1.0 for oral and 0.14 for dermal contact) for PCBs were obtained from Health Canada (2010b). The oral slope factor for potential carcinogenic risk was obtained from the USEPA (1997).

Table 2.1 Receptor Characteristics

Characteristic	Units	Receptor Characteristics					Reference
		Infant	Toddler	Child	Teen	Adult	
Age group duration	years	0.5	4.5	7	8	60	Health Canada 2010a
Body weight	kg	8.2	16.5	32.9	59.7	70.7	Health Canada 2010a
Water ingestion rate (while swimming)[a]	mL/day	100	100	100	100	100	USEPA 2011
Sediment Ingestion Rate[b]	mg/day	10	10	10	10	10	Calculated
Skin Surface Area (feet)	cm^2	250	430	720	1050	1130	Richardson 1997
Sediment Adherence Factor (feet)[c]	mg/cm^2/ event	0.1	0.1	0.1	0.1	0.1	Health Canada 2010a

Notes:

[a] Water ingestion rate while swimming equal to the mean value for children (37 mL/45 min) calculated for a 2 hour daily exposure duration (equals approximately 100 mL/day).

[b] Sediment ingestion rate calculated as the water ingestion rate (100 mL/day) x total suspended solids (TSS; estimated to be 100 mg/L). Note that although TSS data was not available for Old Dump Pond, a value of 26 mg/L was obtained from a downgradient stream. Since the sediments in Old Dump Pond are very soft, it was conservatively estimated that TSS would be 100 mg/L due to re-suspension while wading.

[c] Sediment adherence factor for feet assumed equal to the soil loading to hands value.

The calculated SSTL for carcinogenic effects of PCB exposure from sediments in Old Dump Pond is 769 mg/kg and the SSTL for non-carcinogenic effects is 1,285 mg/kg. Therefore, a final SSTL of 770 mg/kg (rounded up from 769 mg/kg) was selected as a conservative SSTL for human exposure via the fish consumption pathway (i.e., $SSTL_{HH}$) to sediments of Old Dump Pond. The calculation spreadsheets are provided in Appendix B. Based on analytical results from previous investigations, concentrations of PCBs in sediment from Old Dump Pond do not exceed 770 mg/kg.

Ecological Receptors

In 2009, Stantec conducted a qualitative ecological risk assessment for Old Dump Pond (Phase II/III Environmental Site Assessment, Human Health and Ecological Risk Assessments and Remedial Action/Risk Management Plan for Former US Military Site and Residential Subdivision at Hopedale, Labrador, Stantec, May 17, 2010). Based on a review of aquatic toxicity studies, the risk assessment concluded that the concentrations of PCBs in pond sediment were not resulting in an unacceptable risk to fish or fish eating birds (based on measured PCBs in fish tissue). The PCB tissue concentrations were consistently below the lowest observed adverse effect concentration (LOAEC) (for body burden) found in published literature for fish. Removal of sediment was therefore not considered necessary from an ecological risk perspective.

Hopedale Harbour

Human Health

In order to derive a PCB concentration in marine sediment that would be protective of humans consuming fish from Hopedale Harbour, a sediment quality objective was back-calculated from public health based fish tissue limits for human consumption. For this purpose, Stantec adopted the Ontario Ministry of Environment (MOE) fish consumption guideline of 0.105 mg/kg PCB in fish tissue for the calculation (Ontario MOE, 2013). The back-calculation of a sediment concentration was based on the following equation:

$$C_{sediment} = \frac{C_{fish} \times (\%OC/100)}{(\%lipid/100) \times (\text{normalized fish:sediment PCB ratio})}$$

Where:

$C_{sediment}$ = Maximum concentration of PCBs in sediment to reach MOE guidance
C_{fish} = Concentration of PCBs in fish (mg PCB/kg tissue) (MOE)
% lipid = kg lipid/kg fish tissue x 100 % = 10 % for Hopedale fish
%OC = kg organic carbon / kg sediment = 12 %

Normalized fish: sediment PCB ratio = Average lipid-normalized PCB concentration recorded in rock cod, sculpin and flatfish in Basins 1 and 2 of Hopedale Harbour (mg PCB/kg lipid) / Average carbon-normalized PCB concentration recorded in sediment in Basins 1 and 2 of Hopedale Harbour (mg PCB/kg TOC) = 1.80223

The average lipid-normalized PCB concentrations in fish were determined by averaging the geometric means of the lipid-normalized PCB concentrations in fish samples collected from the harbour. In this case, the estimated sediment concentration necessary to achieve the 0.105 mg/kg tissue concentration in rock cod would be approximately 0.06 mg/kg of PCB (assuming continuous exposure of the fish within the affected area).

Ecological Receptors

To date, an ecological risk assessment has not been completed for Hopedale Harbour. Therefore, no SSTLs are available for discussion.

There are currently no provincial guidelines for PCBs in soil or sediment in Newfoundland and Labrador. The Canadian Council of Ministers of the Environment (CCME) has published limits for contaminants in environmental media that are intended to maintain, improve, and/or protect environmental quality and human health at contaminated sites in general. These guidelines include numerical values for the assessment and remediation of soil and water in the context of agricultural, residential/parkland, commercial, and industrial land uses and of sediment in freshwater or marine environments. Environmental soil, sediment and water quality guidelines are derived using toxicological data to determine the threshold level to key receptors. These criteria include the CCME Interim Sediment Quality Guidelines (ISQGs) and Probable Effects Levels (PELs) for freshwater and marine sediment, 2001.

While higher than the CCME ISQGs, the CCME PELs represent a more realistic benchmark for evaluation of effects at operational harbours with existing contaminant sources. The latest update of the CCME ISQGs and PELs is available online at http://ceqg-rcqe.ccme.ca/. The CCME ISQG for PCBs in marine sediment is 0.0215 mg/kg while the PEL is 0.189 mg/kg.

3.0 OVERVIEW OF SITE CONDITIONS

The site is broadly composed of two sediment impacted areas: a freshwater pond (Old Dump Pond) and the harbour of Hopedale. The extent of impacts in each these areas is described below.

Old Dump Pond

Old Dump Pond is recharged from the northwest end of the pond and discharges to the southeast corner through a small stream. The stream ultimately discharges into Hopedale Harbour. Impacted sediment deposits are generally found in the top 75 mm and extend horizontally from the shoreline to water depths up to approximately 1.5 m. Higher concentrations are generally found in the east half of the pond (refer to Figure 3.1 and to Drawing No. 121411777.610-EE-02 in Appendix A). The pond measures approximately 120 m by 60 m. In some areas, the sediment is found in continuous deposits, but for the most part is distributed amongst cobbles and small boulders with significant amounts of metal debris.

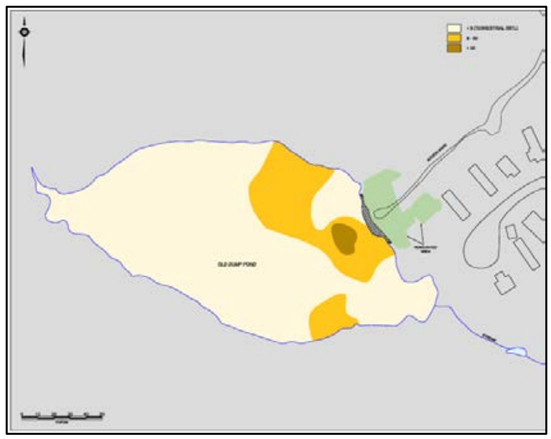

Figure 3-1 PCB Concentrations, Old Dump Pond Upper Sediments

Stantec previously conducted a sediment transport study to determine the mass of impacted sediment migrating from Old Dump Pond, and discharging to Hopedale Harbour via the small stream (report titled *Hydrodynamic and Sediment Transport Modeling Study Hopedale Harbour*. Stantec, July 2014). The study concluded that there is no indication that the stream is currently a significant source of PCBs to the marine environment.

PCB concentrations in Old Dump Pond sediments have been classified into three broad classes which are specifically associated with disposal controls, should they be removed.

- ***SSTL for soil (9 mg/kg):*** While this SSTL was developed for the terrestrial environment, it is relevant when evaluating remedial options involving potential removal and placement of sediment on land (in which case all material above 9 mg/kg would need to be removed for offsite disposal, in the same manner as PCB soil removed during previous remediation work). This may occur for example, when removing metal debris which may have resulted in co-recovery of underlying impacted sediments.

- ***PCB Regulation classification limit (50 mg/kg):*** This value was referenced as the federal regulatory classification limit which triggers requirements for controls on handling, storage, transport and disposal of materials as a PCB waste. Any sediment recovered above 50 mg/kg would be subject to these regulatory requirements.
- ***SSTL for Old Dump Pond sediments (770 mg/kg):*** This value is protective of the recreational swimmer.

Table 3.1 summarizes the areas of impacts for the various concentrations.

Table 3.1 Summary of Sediment Impact Areas, Old Dump Pond

Sediment PCB Concentration (mg/kg)	Area of Impacted Sediment (m2)
< 9	15,200
9 – 50	3,500
50 – 770	250
> 770	0

Old Dump Pond has an approximate area of 18,950 m^2. As shown in Table 3.1, approximately 3,750 m^2 of sediment has PCBs concentrations exceeding the terrestrial SSTL of 9 mg/kg and 250 m^2 of sediment has PCBs concentrations exceeding the federal regulatory classification limit of 50 mg/kg. No exceedances of the SSTL for sediments derived for the swimming/wading human exposure scenario (770 mg/kg) were detected.

<u>Hopedale Harbour</u>

Impacts to Hopedale Harbour above the CCME Marine PEL (0.189 mg/kg) and above the $SSTL_{HH}$ (0.06 mg/kg) are generally found from the north and west shoreline extending outwards towards the sill and forming a polygon measuring approximately 500 m by 900 m, and from the shoreline near the southeastern portion of the town extending approximately 350 m south, as shown on Figure 3-2 and Drawing 121411777.610 in Appendix A.

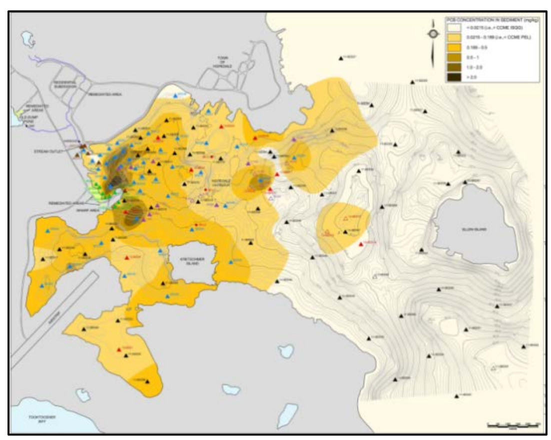

Figure 3-2 PCB Concentrations, Hopedale Harbour Upper Sediments

A PCB "hotspot" where concentrations exceed 1 mg/kg (5x the CCME PEL) is found immediately adjacent to the wharf in water depths ranging from 0.5 m to 13 m below mean sea level.

PCB concentrations in Hopedale Harbour sediments have been classified using the CCME PEL, the SSTL derived for human fish consumption, as well as arbitrary thresholds for general quantification purposes only. The rationale for the various threshold concentrations used to summarize PCB-impacted areas in Hopedale Harbour within this report are as follows:

- **CCME Marine ISQG (0.0215 mg/kg), PEL (0.189 mg/kg), and $SSTL_{HH}$ (0.06 mg/kg).**
- ***0.5 mg/kg, 1 mg/kg and 2 mg/kg***: These values were arbitrarily chosen to show the distribution of PCBs in harbour sediments. The values of 0.5 and 1.0 mg/kg are somewhat relevant to the actual ability of dredging equipment to achieve these concentrations after dredging is complete, as discussed further in this document. The 2.0 mg/kg contour demonstrates the area with the highest PCB concentrations. The maximum detected concentration of PCBs in harbour sediments was 4.4 mg/kg in core sediment sample C4-A-09 collected between approximately 90 mm and 100 mm below the sediment surface in 2011.

Table 3.2 summarizes the areas of impacts for the various concentrations.

Table 3.2 Summary of Sediment Impact Areas, Hopedale Harbour

PCB Concentration Range (mg/kg)	Area of Impacted Sediment (m^2)	Cumulative Area (m^2)
0.0215 – 0.189 (CCME ISQG - PEL) (range also includes $SSTL_{HH}$ of 0.06 mg/kg)	637,744	1,146,372
0.189 – 0.5	445,817	508,628
0.5 – 1	41,422	62,811
1 – 2	19,024	21,389
>2	2,365	2,365

PCB impacts in fine black silty sediment have been confirmed through core samples to be predominantly present in the upper sediment layer. In areas where PCB concentrations were less than 1 mg/kg, vertical delineation demonstrated that impacts typically extend to 200 mm below top of sediment surface. For samples with concentrations under 1 mg/kg, the depth of impacts was assumed to be 200 mm. Vertical delineation was not achieved in areas exceeding 2 mg/kg and will need to be verified prior to any final remediation design. However, for the purpose of volume estimates an assumed depth of 300 mm has been used to calculate impact volumes for the >2 mg/kg sediment contour.

Based on the above noted impact depths and the estimated PCB concentration sediment contours (Figure 3-3), the total mass loading of PCB in Hopedale Harbour is estimated to be 12.8 kg. Relative to a purely total mass loading of the overall harbour, it is estimated that 50 % of the total PCB mass loading is present in sediments with concentrations of 0.35 mg/kg and above, 25% is greater than 0.5 mg/kg, and 15 % of the total PCB load is found in sediments above 1 mg/kg (Figure 3-3).

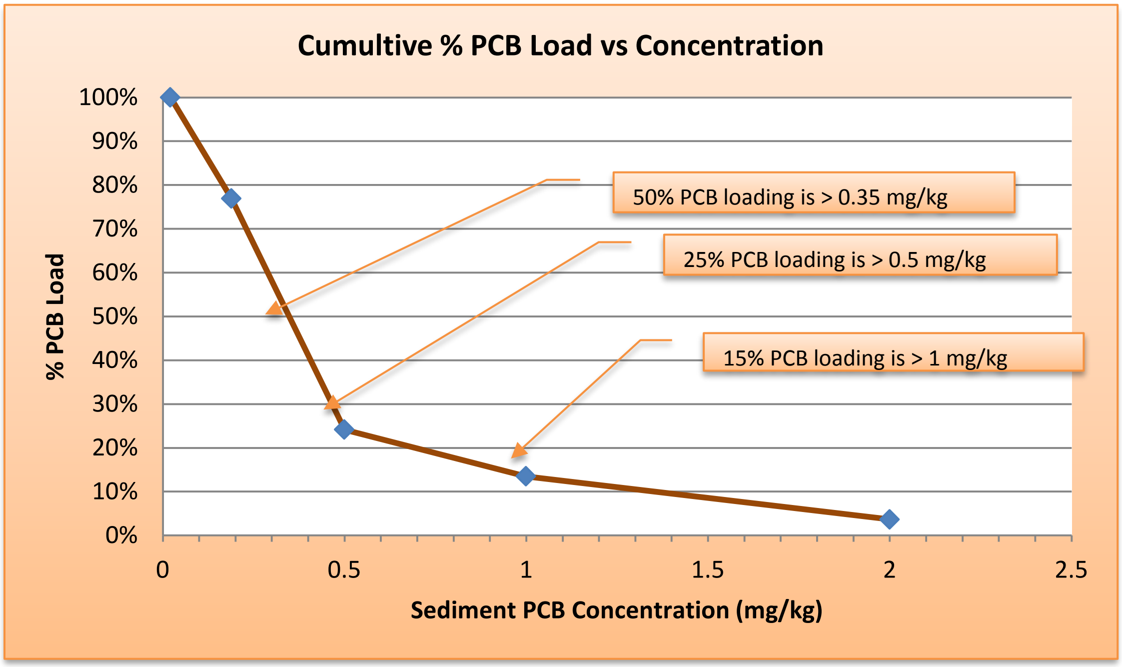

Figure 3-3 Cumulative % PCB Load vs PCB Concentration, Hopedale Harbour

In some areas, the sediment is found in continuous deposits, but is also distributed amongst cobbles and small boulders (near shore areas). Although not documented to date, it is likely that some metallic and other debris is found within the impacted sediment zone. Tides in the area fluctuate over approximately 2 m.

4.0 REMEDIAL OBJECTIVES

4.1 Old Dump Pond

As discussed, there is currently no ecological or human health risk associated with residual sediment PCB concentrations in Old Dump Pond, nor do these concentrations represent a long-term source load to Hopedale Harbor, based on sediment transport studies. Therefore, remediation in Old Dump Pond is not required.

There is a significant amount of metal and other debris in Old Dump Pond that NLDEC may elect to remove and dispose of to minimize physical hazard risks to human receptors. Some PCB impacted sediment with concentrations exceeding 50 mg/kg is found underlying this debris and may be inadvertently recovered with the scrap. Should this occur, sediment would need to be cleaned from surfaces and disposed off-site following federal Regulations. Similarly, if debris associated sediment is recovered with PCB concentrations between 9 and 50 mg/kg, it would also require disposal off-site in a manner similar to past soil remediation.

There is also a small band of soil with PCB concentrations exceeding the terrestrial SSTL of 9 mg/kg located along the northeast shoreline at the end of the access road. The affected area measures approximately 30 m long by 3 m wide and extends vertically 1 m below grade. This strip of soil was left as a buffer between the pond and the soil remediation work conducted in 2012 and 2013. Ultimately, this band of impacted soil requires removal and disposal at an off-site facility. When terrestrial soil remediation occurs here, NLDEC may elect to remove the physical hazards from Old Dump Pond as well. Although not required from a human health and ecological risk perspective, NLDEC may also elect to remove all or a portion of PCB impacted sediment from Old Dump Pond. This would only be considered if the remedial objective is to decrease local sediment PCB mass in Old Dump Pond.

Remedial options presented in this report are based on removal of physical hazards and sediment from the pond or to decrease exposure to PCBs, although as discussed, remediation is not necessary from an ecological or human health risk perspective.

4.2 Hopedale Harbour

As discussed, an ecological risk assessment has not been conducted for Hopedale Harbour. Therefore, the CCME PEL for PCBs in marine sediment (0.189 mg/kg) is considered applicable for the protection of ecological receptors. For protection of human receptors, this analysis was guided by the objective of the Nunatsiavut Government, that the objective is restoration of the harbor to support unrestricted consumption of fish and shellfish. The estimated sediment concentration necessary to achieve the 0.105 mg/kg tissue concentration in rock cod (refer to Section 2.2) (0.06 mg/kg) (assuming continuous exposure of the fish within the affected area) would be considered applicable for protection of human receptors.

Based on Stantec's experience on other sediment dredging projects, achieving post-dredging sediment concentrations below 0.5 mg/kg, or possibly even below 1 mg/kg, may not be technically achievable due to equipment accuracy and re-suspension. Previous studies in the United States have also documented the limited capacity for removal methods to achieve target remediation levels, such as those undertaken by the Sediment Management Working Group in 2006 (S.C. Nadeau, 2nd Meeting of the National Research Council Committee on *Dredging Effectiveness at Superfund Megasites*) as well as conclusions found in "*Evaluating the Effectiveness of Contaminated-Sediment Dredging*", Environmental Science & Technology / July 15, 2008.

Capping has demonstrated to provide more likely success in achieving low residual concentrations. However, in areas where caps are placed over fine sediments (such as is the case with Hopedale Harbour), re-suspension of impacted material with subsequent re-settlement on top of the clean cap is a significant issue that may result in elevated PCB concentrations after completion. Thin caps are also prone to recontamination due to bioturbation (organisms causing impacted sediment to mix with the cap) which may also limit long-term effectiveness. These two issues may be partially controlled through the use of a geosynthetic cover placed over impacted material prior to placement of cap material.

Given the extensive area of Hopedale Harbour with affected sediments exceeding the CCME marine PEL and the $SSTL_{HH}$, the remedial objective will need to consider technology limits, regulatory endorsement and risk management when considering removal technology options.

5.0 IDENTIFICATION OF VIABLE REMEDIAL OPTIONS

For Hopedale Harbour, three viable remedial options were identified which could be used exclusively, or in combination. These included the following:

- Option 1: No further remedial action, long-term monitoring and risk exposure management.
- Option 2: *In-situ* containment, consisting of the placement of a cap to permanently cover sediments, plus long-term monitoring and exposure management.
- Option 3: Removal and disposal, consisting of the dredging of PCB sediments, removal of water from the solids and disposal in an out-of-province licensed facility, plus long-term monitoring and exposure management.

Options 1 and 3 above could also be used at Old Dump Pond should NLDEC elect to remove physical hazards or remove the physical hazards and sediment. As discussed, this is not a requirement but may be considered should the remedial for Old Dump Pond objective change.

5.1 Old Dump Pond

As discussed, no remediation is required at Old Dump Pond from a human health or ecological risk perspective. The following sections present remedial options discussed in the context that it is decided to either: 1.) remove physical hazards from Old Dump Pond; or 2.) remove physical hazards as well as PCB impacted sediment from Old Dump Pond. The latter option would only be considered should decreasing the PCB mass in Old Dump Pond ever become a remedial objective.

The following sections present a general summary of residual risk for the various remedial options for Old Dump Pond sediments and where the remedy would be applied.

5.1.1 Option 1: No Further Action

This option would not provide for any removal of physical hazards or remediation of the PCB-impacted sediments. There are no site enhancements or modifications for this option. Minor uncertainties may need to be addressed through a further round of sampling to confirm the calculations and assumptions made in the risk assessment. Institutional controls will be required including restrictions for residents using the pond (metal debris hazard) and ongoing physical, chemical and biological monitoring to identify movement or alteration in concentration and distribution of PCBs, and to identify future change in conditions which may pose unacceptable risks to ecological receptors.

5.1.2 Option 2: Removal

Removal could be applied to both options discussed in Section 5.1. The first option would address only the physical hazards and any sediment inadvertently removed with the hazards, thus leaving the PCB impacted sediments behind. The second option would involve full removal of physical hazards and sediment in the south eastern portion of the pond.

<u>Alternative 1: Risk Management with Controls, Removal of Debris</u>

This alternative is similar to "Option 1 No Action" in Section 5.1.1 above, except the metal debris would be removed and disposed off-site. The PCB sediments would not be recovered and would remain in place.

<u>Alternative 2: Removal of Sediment and Debris</u>

Removal of material from Old Dump Pond can be completed "in-wet" or "in-dry". The following section describes generally how each approach will occur.

<u>Alternative 2a: "In-Wet" Removal"</u>

In-wet methods are those solutions which allow the overall pond water levels to remain unchanged while the impacted sediment and metal debris is removed. Typically, a dredge specifically designed to recover fine sediments in shallow water is used in conjunction with a shore-based dewatering system (photo 1) to separate and consolidate recovered material.

Photo 1 Dewatering System

The dredge has an adjustable suction head which is set to a designated "cut line" where impacted material is to be removed. Sediment is drawn up with water through the suction head as a slurry and transported to shore via flexible pipeline where it is stored and processed through the dewatering system. Typically, the dewatering process is enhanced using flocculation chemicals that promote better dewatering efficiency. The recovered/dewatered contaminated sediment is then accumulated, dewatered and sent off-site for final treatment or disposal.

Photo 2 MudCat Dredge

There are a variety of commercially available dredges that are on the market. Each has been designed to deal with different sediment situations. For example, a rotary auger suction dredge (such as a MudCat, Photo 2) is often used in industrial settling ponds where there is a very consistent sediment size/range with no material over 75 mm in diameter (e.g., debris or stones). Rotary auger dredges are effective in accurately removing sediment in wide (2.4 m) swaths. However, they are not effective in boulders or debris areas as it causes the auger to bind up or clog. Other dredges, such as the Amphibex (Photo 3) are more suited for recovering sediment which is comingled with cobbles or debris. These units use an excavator head equipped with suction lines to remove debris while at the same time recovering sediment. However, these units have a limited bucket size, so they take more time to complete a designated area.

Photo 3 Amphibex dredge

Alternative 2b "In-Dry" Removal

This solution would require the pond levels to be lowered to fully expose the debris so it could be recovered with excavation equipment. The pond would be dewatered by installing a temporary water-dam (AquaDam, Photo 4) across the pond to separate sediments below the remedial objective targets (which are likely at least the >50 mg/kg material). Water would then be drained from the pond through a combination of gravity flow and pumps.

Photo 4 Temporary AquaDam

Once dewatered, the debris and some impacted sediment would be removed by excavators. It may be necessary to deploy temporary "swamp mats" to provide equipment support in areas of low sediment bearing capacity. Sediment would be removed to depths of approximately 0.1 m to 0.2 m below existing grade.

Photo 5 Water Pumps

Cobbles would be transferred along with debris to a constructed cleaning area where sediments would be washed with water. The cleaning area would consist of a 40 mil geosynthetic liner, sloped and graded to a sump where PCB impacted wastewater would be collected and treated; post-treated washwater would be discharged back into the environment after verifying that it met environmental surface water discharge limits.

Photo 6 Sediment Removal by Excavator

Washed cobbles and boulders would either be returned to the pond, or placed on land. Metal and other recovered debris would be placed in totes pending final off-site disposal. The dewatered PCB sediment recovered from excavation and washing would be placed in “tote-bags” for disposal off-site.

Special considerations and requirements:

- Magnetometer survey is needed to verify there is no debris along the alignment of the AquaDam.
- Geotechnical testing is needed to verify the sediment has suitable bearing capacity along the alignment of the AquaDam for Old Dump Pond.
- The hydrology of the upgradient watershed would need to be evaluated to estimate the flows during construction period for sizing pumps.
- An ecological survey and Environmental Assessment would be required to identify significant potential adverse effects during the dewatering and dredging.

5.2 Hopedale Harbour Sediment Remediation

The following sections provide a general summary of approach for each potential sediment remedial option for Hopedale Harbour.

5.2.1 Option 1: No Further Action

In this option, sediments would remain in place without further remediation. There are no site enhancements or modifications associated with this option. Uncertainties may need to be addressed through additional monitoring to confirm the calculations and assumptions made in the risk assessment. Institutional controls may be required including fish consumption restrictions (for catches within the harbour), as well as ongoing physical, chemical and biological monitoring to identify movement or alteration in concentration and distribution of PCBs and to identify future change in conditions which may pose unacceptable risks to human receptors. A Hydrodynamic and Sediment Transport Modelling Study was recently completed by Stantec to determine the potential for long-term dispersion effects of residual PCBs in Hopedale Harbour (reported under separate cover). The outcomes of the study demonstrated that PCB contaminated sediments in the harbour have a very low potential to migrate to the coastal areas. As such, this option does not represent a long term risk for marine organisms beyond the harbour, and there would be a no requirement to impose a fishing advisory for coastal areas. PCBs are left in place so there is no reduction of toxicity or contaminant mass in the harbour.

5.2.2 Option 2: Capping

This option would be completed “in-wet”, where a protective cap would cover some, or all of the impacted sediments directly in-place to remove the direct contact pathway. The cap would consist of a geosynthetic reactive fabric (as described above for Old Dump Pond) overlain by successive layers of granular aggregate being placed over impacted sediment. Given the depths (0.5 m to over 6 m below surface) and ship-based deployment methods needed to place material, cap thicknesses will be at least 0.3 m and likely up to 0.5 m. The cap configuration would need to have several discrete aggregate sizes so as not to puncture the geosynthetic or displace the sediment causing "mud waves" (sediment that wells up adjacent to the placed aggregate due to displacement). For the purpose of the option assessment, it is assumed that the cap would consist of a geosynthetic covered with fine sand, followed by 25 mm diameter gravel, and covered with a coarser 100 mm surge. The material would be placed using a commercially available barge-mounted aggregate spreader. A local aggregate source would need to be established to supply the large amount of granular material.

Larger size aggregate and cover thickness may be required near the wharf where ship thrusters cause significant turbulence/scour at depth. Further assessment of depths adjacent to the existing wharf will be required to ensure that the cap will not compromise draft and limit ship unloading. In the event that the cap will compromise local ship draft depth needs, some impacted material may need to be dredged, dewatered and disposed off-site.

Alternative 2a: Capping all PCB Impacted Areas (above CCME PEL and $SSTL_{HH}$)

This alternative involves capping all areas above the CCME PEL and $SSTL_{HH}$. Further, bulk placement of a bulk aggregate would very likely suffocate all existing benthic organisms in the short term and leave a completely different marine habitat (i.e., coarse aggregate vs existing fine silt). Placement is also expected to cause impacted sediment re-suspension which may redeposit on the cap after placement. As such, residual sediment concentrations may still result in elevated PCB concentrations in fish tissue through biomagnification effects, which may cause risks to human receptors.

Alternative 2b: Partial Capping

This alternative involves capping the areas above an arbitrary value (5x CCME PEL of 0.189 mg/kg) of 1 mg/kg (i.e., the "hotspot") representing 15% of the total PCB mass load for the harbour. Residual impacts would remain and institutional controls (limitations on consumption of fish/invertebrates) and long-term monitoring would be implemented. Stantec's recent contaminant flux study determined there is limited long-term potential for residual PCBs in the harbour to migrate to coastal areas. Consumption restrictions for coastal catches would not be required.

PCBs are left in place so there is no reduction of toxicity or contaminant volume. Long-term monitoring of the capped area would be needed to ensure long-term effectiveness. As partial capping leaves other PCB impacted areas exposed, there would be no reduction in human health risk and institutional controls will be required including fish consumption restrictions for catches from the harbour, as well as long term monitoring of fish and sediment for PCBs.

5.2.3 Option 3: Removal

Because of the inherent depths associated with impacted sediment, only "in-wet" methods can be used. Because of the significant depths, specialized dredges will be required to recover the impacted sediment. One common type of dredge is a cutter-suction dredge which has a positional auger head that cuts sediment to a pre-specified depth; the sediment is then sucked up to surface and then to shore through pipelines. For the thin layer needed to be removed (i.e., the top 300 mm) these dredges are expected to generate a significant volume of water (in excess of 100 parts water to 1 part sediment) so a large impoundment is needed to contain, settle, and dewater recovered material. These dredges are commonly used in harbour dredging, particularly in Europe, where contaminated deposits are often found in navigable waterways. Because the sediment is very fine, these dredges tend to bring up much more than the target 0.2 m thickness; for the purpose of this option analysis, it is assumed that on average, dredges will remove a thickness of at least 0.5 m and up to 1 m on each successive pass.

Photo 7 Cutter Section Dredge

Photo 8 Pipeline

An alternative to an auger-suction type dredge is to use a specialty designed clam-type dredge, known as a CableArm (see Photo 9). These units are able to remove a very specific thickness of material (minimum 300 mm) leaving a very level excavation. The bucket is specifically designed to form watertight seal to allow the water/ sediment to return to surface without causing significant contaminated sediment re-suspension. At surface the sediment is placed in an open barge where it can be dewatered and consolidated for shipment south. This unit takes much longer to remove sediments, but has other benefits including lower operating costs, lower mobilization costs, lower amounts of water to treat (range of 1 part sediment to 1 part water or less depending on sediment and cut depth), lower re-suspension issues, accuracy, and no requirements for large land-based holding cells and dewatering systems.

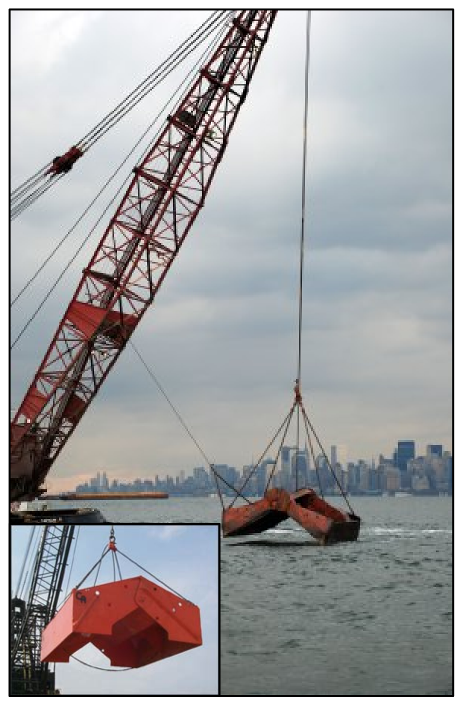

Photo 9 CableArm

As noted previously, dredging technologies are unlikely to achieve remediation endpoints that will allow unrestricted consumption of fish. Further, dredging will not likely achieve CCME PEL or $SSTL_{HH}$ concentrations for most impacted areas due to re-suspension / deposition, and dredge head positioning accuracy. As such, the use of removal techniques will most likely result in PCBs at concentrations that require a fish consumption advisory as there would remain a high risk through the consumption pathway. Recovered dredged material could be managed in one of three ways, as described below.

Photo 10 CableArm and barge.

Alternative 3a: Removal, Dewatering, On-site containment

This Alternative involves the removal of sediment with dredges and transferring the water/sediment slurry to shore where it would be placed in a temporary processing cell sized to production capacity of the dredge ship. As noted above, rotary-auger suction dredges usually generate large volumes of water relative to the amount of sediment actually recovered and would need significant shore-based containment cells to hold the sediment/water slurry for further dewatering. For this project, such a cell would be several hectares in size.

Photo 11 Impoundment area.

There is limited land in which to construct a cell for this type of operation, and is considered not viable due to site constraints.

The second type of recovery method would be with the CableArm clam-type bucket dredge. Recovered material would be transferred by barge to a land-based dewatering system. Post-treated water would be returned to the ocean. The dewatered sediment would be contained permanently in an on-site confined disposal facility.

It is not clear at this stage what size the holding cell would be as its capacity is influenced by the rate at which sediment/water can be separated and treated. Dewatered sediments would then be placed in a permanent on-site confined disposal cell. However, given the limited land availability to construct a cell, and the limited sources of aggregate to construct a cell, this may not be an implementable option. This Alternative is further divided into two options based on residual PCB concentrations, which include the following:

- Alternative 3a(i), Removal of Material Above CCME PELs or $SSTL_{HH}$ (if possible).
- Alternative 3a(ii), Removal of Material Above 1 mg/kg.

Both alternatives will require some institutional controls including fish consumption restrictions for Hopedale Harbour catches, as well as long term monitoring of fish and sediment for PCBs.

Alternative 3b: Construction of an Underwater Containment Cell

This option is a relatively new approach in Canada for management of impacted sediments underwater. The concept has been used in the United States and more recently being proposed for the Randle Reef remediation project in Hamilton Harbour. The method involves establishing an underwater containment area where contaminated sediments are dredged, transferred, and placed. The material is contained either within a sheet pile wall cell (as in the case of Randle Reef), a section of shoreline reformed as a containment cell (such as a small bay), or an underwater cell constructed of granular material derived from clean sediment or land-based borrow material. Contaminated dredged sediment would be placed in the underwater cell and covered with a clean granular cap. Once completed, the cell would be monitored to verify it remains intact. Also, a benthic sampling program may also need to be undertaken to monitor the health of fish and benthic organisms after dredging and capping is complete.

This option has several challenges including the need to site a disposal cell location which is acceptable to the regulators and community and, more importantly, the ability to place impacted material into the cell without loss of PCB impacted fines. This latter consideration is unlikely to be resolved for a remedy involving an underwater cell and so it has been removed from further consideration. The remaining option would be to construct a shoreline containment cell, like that proposed for Hamilton, made from sheet pile walls that would be filled and capped. This option would require community acceptance and regulatory approval.

This alternative can be applied to two conditions based on residual PCB concentrations, which include the following:

- Alternative 3b(i), Removal of Material Above CCME PEL and/or $SSTL_{HH}$ (not likely possible).
- Alternative 3b(ii), Removal of Material Above 1 mg/kg.

These alternatives will both be subject to institutional controls as noted for option 3a.

Alternative 3c: Removal Dewatering, Disposal Off-site

This option would be similar to Alternative 1, above. However, treated material would be shipped off-site and disposed of out of Province. At this stage of analysis, it is assumed that the material would have to go to Quebec which would cause logistical issues matching site production (dredging/dewatering/stockpiling) with shipment schedules south. This alternative is further divided into two options based on residual PCB concentrations, which include the following:

- Alternative 3c(i), Removal of Material Above CCME PELs (not likely possible)
- Alternative 3c(ii), Removal of Material Above 1 mg/kg.

Both alternatives will be subject to institutional controls as noted for option 3a.

This option would require significant dewatering of sediment on-site prior to shipment south to manage tipping fees at the final receiving landfill. Prior to implementing the removal options, the following special considerations and requirements will need to be addressed:

- Magnetometer survey is needed to verify there is no debris or large boulders.
- A temporary containment cell, and final confined disposal cell would need to be sited, designed, and permitted.
- Logistics, including vessel refueling will need to be considered along with its inherent risks.
- An ecological survey and Environmental Assessment would be required to satisfy regulatory requirements, and identify significant potential adverse effects during the dredging and disposal or shipment south.

6.0 SCREENING OF REMEDIAL OPTIONS AND TECHNIQUES

In total, eight general metrics have been established in consultation with the stakeholders, encompassing statutory requirements as well as other gauges to determine overall feasibility and acceptability of various options.

1. **Overall Protection of Human Health and the Environment** addresses whether an option adequately protects human health and the environment. This criterion can be met by reducing or eliminating contaminants, or by reducing people's exposure to them. This metric considers protection of ecological health at a population level.
2. **Compliance with Applicable or Relevant and Appropriate Requirements**, referred to as ARARs, ensures that each project complies with federal, provincial and local laws and regulations.
3. **Long-term Effectiveness and Permanence** evaluates how well an option will work in the long term, including how safely remaining contaminants can be managed.
4. **Reduction of Toxicity, Mobility, or Volume through Treatment** addresses how well the option reduces the harmful effects, movement and amount of contaminants through permanent treatment methods.
5. **Short-term Effectiveness** evaluates how quickly the cleanup can be done, as well as its potential impacts on cleanup workers, area residents, and the environment.
6. **Implementability** evaluates the technical difficulty in building and operating the cleanup system and whether materials and services are routinely available to complete the project.
7. **Cost** includes estimated capital or startup costs. An example is the cost of temporary buildings/construction camps, treatment systems and mobilization. It also considers cost to implement the cleanup and operate and maintain it over time. Examples include laboratory analysis, equipment (dredges, containment cells, etc.) repairs, and personnel hired to

operate equipment. A cleanup is considered cost effective if its costs are proportionate to its overall effectiveness.

8. **Government Acceptance** is whether the federal government and the Newfoundland and Labrador Department of Environment and Conservation agrees with the recommended option.
9. **Stakeholder Input** evaluates how well stakeholders and the Nunatsiavut Government accepts the option. As this current study is evaluating only the environmental risk and technical aspects of residual PCB impacts, Stakeholder input is not addressed at this stage.

These considerations are generally assessed within two criteria:

Threshold Criteria: A pass/fail class criteria. If an option fails one of the threshold criteria, then it is not evaluated further.

Balancing Criteria: Criteria that must ultimately be weighed against each other in order to determine the best remedial solution.

All options and associated techniques must meet the Threshold Criteria in order to be considered further in the Balancing Criteria. Threshold Criteria include the following metrics:

- Overall Protection of Human Health and the Environment
- Compliance with Applicable or Relevant and Appropriate Requirements;
- Implementability; and,
- Long-term effectiveness and Performance.

The remaining metrics (Reduction of Toxicity, Short Term Effectiveness, Cost, Government Acceptance and Stakeholder Acceptance) are considered in the Balancing Criteria.

The positive aspects (pros) and negative aspects (cons) as well as any important considerations are identified for a number of aspects within each of the balancing criteria.

The following federal government policies and federal environmental legislation would apply to the three basic remedial options under consideration. Compliance with applicable legislation and policy is a mandatory threshold criterion. Federal legislation that may be applicable to one or more of the options includes:

- *Canadian Environmental Assessment Act*;
- *Canadian Environmental Protection Act*;
- *Disposal at Sea Regulations*;
- *Navigable Waters Protection Act*;
- *Interprovincial Movement of Hazardous Waste Regulations*;
- *PCB Regulations*;

- *Fisheries Act*; and,
- *Transportation of Dangerous Goods Act*.

Provincial legislation will depend upon the option selected, as any removal or containment in a confined disposal facility could involve Newfoundland and Labrador or Quebec.

7.0 DETAILED EVALUATION OF OPTIONS

7.1 Old Dump Pond

As discussed, PCB impacted sediment in Old Dump Pond is not expected to pose unacceptable risks to ecological or human receptors. Therefore, remediation is not required. Evaluation of remedial options is provided here for the following reasons: 1) should the removal of physical hazards from a safety perspective become a remedial objective; or 2) should the removal of impacted sediment from the perspective of reducing PCB mass in the pond become a remedial objective.

As noted in Section 4, there are two broad options for addressing sediments and removing the physical hazards in the pond. These include one, or a combination of the following:

- No further action; and/or
- Removal (either “in-wet” or “in-dry”).

The “No further action” option is considered viable as residual environmental risks will not adversely affect human or ecological receptors. However, the debris in the pond will represent a residual physical hazard requiring institutional controls to be established to restrict swimming.

Removal of physical hazards would be an effective solution as it would eliminate the need for restrictions on swimming. The approach will meet applicable regulatory and relevant requirements. Given the shallow nature of the pond, removal in-dry could be implemented within a one year construction season and permanently remove physical (debris) hazards. Some impacted sediment is expected to be recovered during debris removal. Depending on the location, recovered sediments may require off-site disposal (i.e., areas with PCB concentrations above 9 mg/kg). As discussed, additional sediment removal may be optionally included to reduce the existing PCB residuals in the pond but is not considered necessary from a human health or ecological risk perspective.

7.2 Hopedale Harbour

Remediation of Hopedale Harbour is very complicated and would challenge all active remediation methods given the overall harbour area and depths to impacted sediments. Table C.1, Appendix C, presents a summary of Threshold and Balancing criteria considerations for each of the three options and their associated alternatives. The outcome of this summary to advance as a potential option is presented in Table C.2, Appendix C. Given that it will be technically impossible to achieve residual PCB concentrations in the harbour of less than 0.06 mg/kg, all options will result in a fish consumption advisory. Based on assessment against each of the Threshold and Balancing Criteria, the following Options have been forwarded for consideration. It is noted that the selection of the 1 mg/kg is based on the practicality of cost effectively removing at least 15 % the total PCB contaminant mass.

- No Further Action, monitoring and institutional controls;
- Capping – all sediments over 1 mg/kg;
- Removal – all sediments over 1 mg/kg and placement in shoreline sheet pile wall cell; and
- Removal – all sediments over 1 mg/kg and disposal off-site.

Cost estimates for each of the options are illustrated in Figures 7-1 and 7-2. As neither a site nor volume can be determined for the option of disposal in a shoreline sheet pile wall cell without further consultation and investigation, this cost has not been prepared. However, costs are presented for capping options and Removal/Off-site disposal.

7.2.1 No Further Action

As there are no construction costs associated with this remedy, costs are strictly associated with monitoring of sediments and fish to identify changes or trends in PCB concentrations. The estimate assumes that one monitoring event would consist of the collection of 30 sediment and 30 fish tissue samples. The frequency of monitoring would be determined based on a review of all available analytical data. The cost is estimated at $100,000 per monitoring event.

7.2.2 Capping

Figure 7-1 presents the capital costs to cap PCB impacted sediment depending on the relative concentrations. The estimate assumes the rock aggregate needed for the cap can be generated in the community using a portable crusher. Further, it is assumed that cost efficiencies will be available as cap areas are increased. Depending on the area to be capped, annual monitoring may be needed, and is estimated at $100,000 per year.

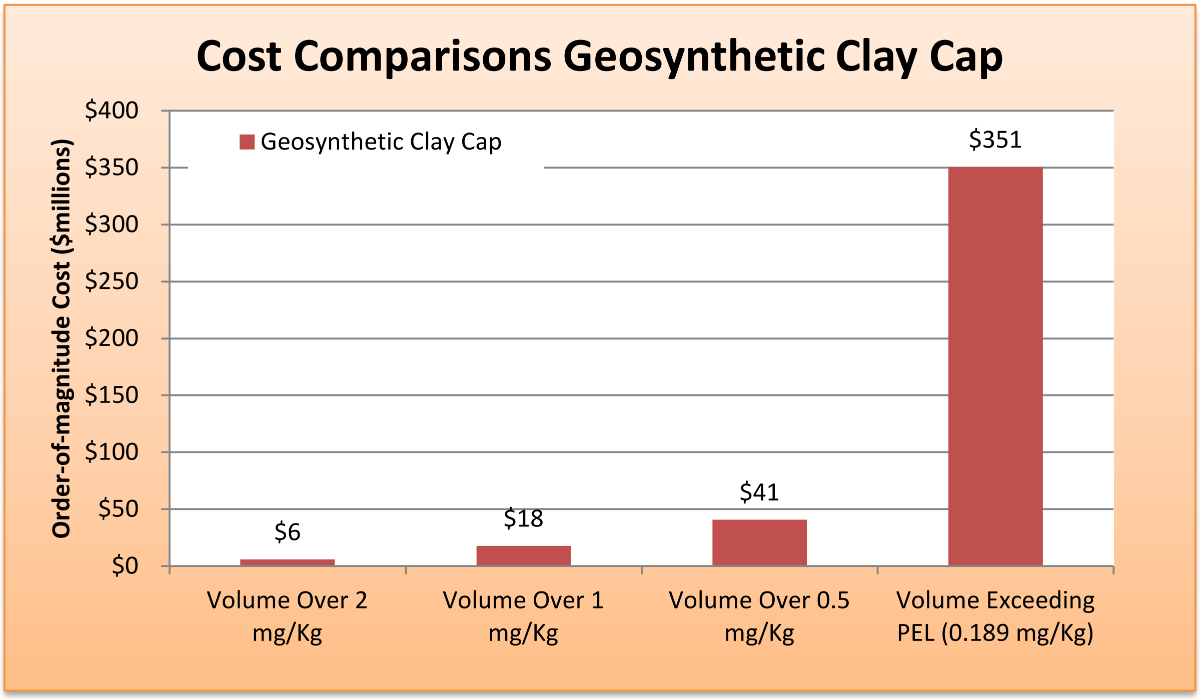

Figure 7-1 Cost Estimates for Capping, Hopedale Harbour

7.2.3 Removal

Estimates for dredging are based on use of a CableArm system. For estimating purposes, it is assumed that the dewatering cost is 50% of the cost for dredging/shipping to shore. It is also assumed that the material will be subsequently shipped to Quebec for final disposal. Depending on the area to be dredged, annual monitoring may be needed, and is estimated at $100,000 per year.

Environmental dredging or capping of remote northern harbors has not been undertaken in a significant way and actually costs are not available. For the purpose of preparing estimates, Stantec assembled dredging and capping costs for southern locations and developed an average cost per in-situ cubic meter. For dredging, costs were prepared to account for a significant mobilization cost(with multiple events depending on area to be addressed), operating in a remote location in a short construction season with no access to necessary infrastructure or fueling, specialized dredging equipment and dewatering, as well as waste sediment transportation to the south.

Capping estimates were also prepared by initially constructing a 300 mm thick cap underlain by a geosynthetic reactive liner in a southern context, and added considerations to adjust for northern/remote conditions, short working times, and the significant cost to quarry and crush suitable aggregate for cap cover. A comparison of general order-of-magnitude costs for capping versus dredging and removal is presented in Figure 7-2 below.

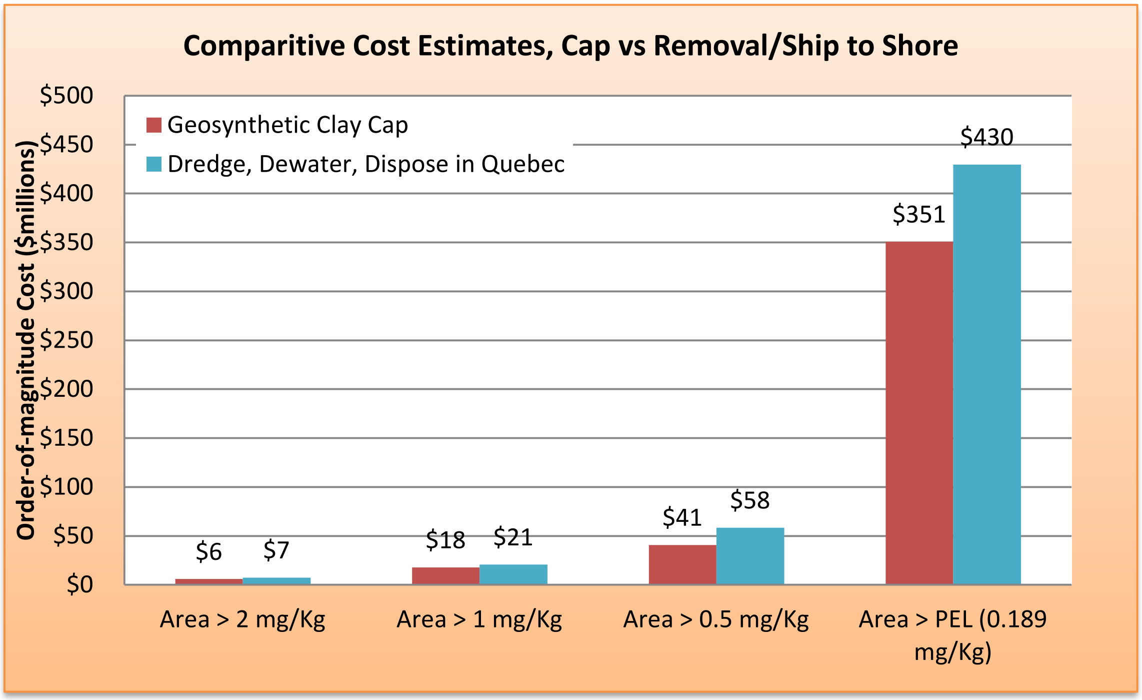

Figure 7-2 Cost Estimates for Dredging and Off-site Disposal, Hopedale Harbour

8.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the residential soil remediation objectives, residual PCB impacted soil along the western shoreline (exceeding the residential SSTL of 9 mg/kg) requires remediation. No remediation of Old Dump Pond sediment is considered necessary, however, from a human health or ecological risk perspective. If the objective for Old Dump Pond is to eliminate physical hazards associated with remnant debris, it may be necessary to dispose of PCB impacted sediment that may be inadvertently removed with the debris. As sediment in debris areas typically exceeds 9 mg/kg, it will require off-site disposal. Any sediment above 50 mg/kg will also need to be managed in accordance with federal regulatory requirements.

All options described for Hopedale Harbour will not result in increased long-term risks beyond the harbour, as studies have demonstrated the PCB impacted sediments are relatively stable and not prone to significant movement. Further, all options presented none will result in unrestricted consumption of Hopedale Harbor fish catches as none can practically achieve residual concentrations less than the $SSTL_{HH}$ of 0.06 mg/kg. As such, no active remediation is recommended at this time unless a more obtainable remedial objective is established. Once a more obtainable remedial objective is determined, a target remediation zone can be identified. Costing should then be refined through discussions with specialty marine contractors.

As an example, Table 8.1 provides alternative sediment remediation endpoints that would realize different fish consumption allowances based on residual PCB sediment concentrations in Hopedale Harbour. This example is dependent upon the starting assumptions, as indicated.

Table 8.1 Alternative Sediment Quality Targets for Hopedale Harbour

Target Fish Tissue Concentration (mg PCB/kg fish tissue)	Target Sediment Concentration (mg PCB/kg sediment)		
	Fish Fillet (assumed 2% lipid)	Fish Fatty Tissue (assumed 10% lipid)	Fish Liver (assumed 30% lipid)
0.105	0.35	0.07	0.023
0.211	0.70	0.14	0.047
0.844	2.81	0.56	0.188

Notes:
Assumptions: Sediment organic carbon content is 10%; fillet lipid content is 2% or less; liver lipid content is 30% or greater; BSAF relating PCBs in fish lipid to sediment organic carbon is 1.5.

The calculations summarized in Table 8.1 underscore the difficulty of achieving effective remediation that would allow even limited consumption of fatty tissues, such as rock cod liver. The required residual PCB concentrations in sediment are exceedingly stringent (less than 0.06 mg PCB/kg sediment). On the other hand, remediation to support limited consumption of lean fish tissue, including rock cod fillet, could potentially be feasible and meet the MOE consumption guidelines. In this case, target PCB concentrations below 0.35 mg/kg sediment would be required, but could potentially be achieved with removal of the sediment PCB "hotspot" in inner harbor areas. However, an advisory against eating fish liver or other fatty organs would remain for the Harbor.

Based on the outcomes of the study, Stantec recommends the following:

- Meet with regulators and stakeholders to determine potential issues which would further limit options identified, or identify other considerations that will need to be considered/ implemented once a specific option is selected as a final remedy.
- Determine the preferred remedial objective(s) and option(s) and develop a path forward.

9.0 CLOSURE

This report documents work that was performed in accordance with generally accepted professional standards at the time and location in which the services were provided. No other representations, warranties or guarantees are made concerning the accuracy or completeness of the data or conclusions contained within this report, including no assurance that this work has uncovered all potential liabilities associated with the identified area of review.

This report provides an evaluation of options for selected environmental conditions associated with the identified portion of the site that was assessed at the time the work was conducted and is based on information obtained by and/or provided to Stantec at that time. There are no assurances regarding the accuracy and completeness of this information. All information received from the client or third parties in the preparation of this report has been assumed by Stantec to be correct. Stantec assumes no responsibility for any deficiency or inaccuracy in information received from others.

The opinions in this report can only be relied upon as they relate to the condition of the portion of the identified property that was assessed at the time the work was conducted. Activities at the property subsequent to Stantec's assessment may have significantly altered the property's condition. Stantec cannot comment on other areas of the property that were not assessed.

Conclusions made within this report consist of Stantec's professional opinion as of the time of the writing of this report, and are based solely on the scope of work described in the report, the limited data available, and the results of the work. They are not a certification of the property's environmental condition. This report should not be construed as legal advice.

This report has been prepared for the exclusive use of the client identified herein and any use by any third party is prohibited. Stantec assumes no responsibility for losses, damages, liabilities or claims, howsoever arising, from third party use of this report.

The locations of any utilities, buildings and structures, and property boundaries illustrated in or described within this report, if any, including pole lines, conduits, water mains, sewers and other surface or sub-surface utilities and structures are not guaranteed. Before starting work, the exact location of all such utilities and structures should be confirmed and Stantec assumes no liability for damage to them.

The conclusions are based on the site conditions encountered by Stantec at the time the work was performed at the specific testing and/or sampling locations, and conditions may vary among sampling locations. Factors such as areas of potential concern identified in previous studies, site conditions (e.g., utilities) and cost may have constrained the sampling locations used in this assessment. In addition, analysis has been carried out for only 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 does not warrant against undiscovered environmental liabilities nor that the sample results are indicative of the condition of the entire site. As the purpose of this report is to identify site conditions which may pose an environmental risk; the identification of non-environmental risks to structures or people on the site is beyond the scope of this assessment.

Should additional information become available which differs significantly from our understanding of conditions presented in this report, Stantec specifically disclaims any responsibility to update the conclusions in this report.

Respectfully submitted

STANTEC CONSULTING LTD.

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Principal, Environmental Remediation

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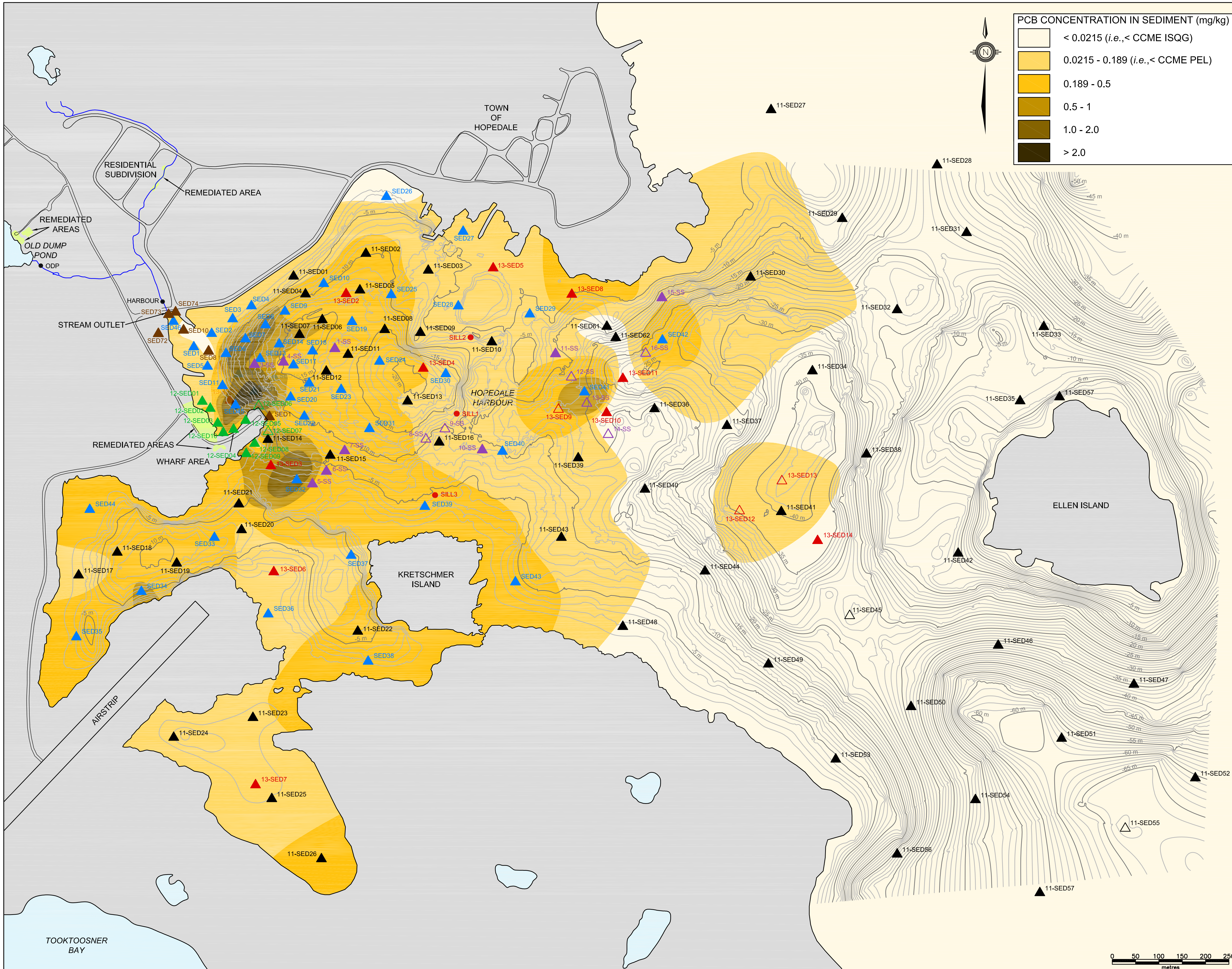
APPENDIX A

Drawings

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

CLIENT: NEWFOUNDLAND AND LABRADOR DEPARTMENT OF ENVIRONMENT AND CONSERVATION	SCALE: 1:50,000	DATE: MAY 30, 2014	REV. No. 0
	DRAWN BY: N.M.	EDITED BY: -	CHECKED BY:
PROJECT TITLE: REMEDIAL OPTIONS PCB CONTAMINATED SEDIMENTS, HOPEDALE, LABRADOR	DRAWING No: **121411777.610-EE-01**	CAD FILE: 121411777_610-EE-01.DWG	
DRAWING TITLE: SITE LOCATION PLAN	Stantec		

30MAY14 9:00AM



LEGEND

- GRAB SEDIMENT SAMPLE LOCATION (STANTEC, 2013)
- UNSUCCESSFUL GRAB SEDIMENT SAMPLE LOCATION (STANTEC, 2013)
- WATER SAMPLING LOCATION (STANTEC, 2013)
- GRAB SEDIMENT SAMPLE LOCATION (NATECH, 2012)
- UNSUCCESSFUL GRAB SEDIMENT SAMPLE LOCATION (NATECH, 2012)
- GRAB SEDIMENT SAMPLE LOCATION (STANTEC, 2012)
- UNSUCCESSFUL GRAB SEDIMENT SAMPLE LOCATION (STANTEC, 2012)
- GRAB SEDIMENT SAMPLE LOCATION (STANTEC, 2011)
- UNSUCCESSFUL GRAB SEDIMENT SAMPLE LOCATION (STANTEC, 2011)
- GRAB SEDIMENT SAMPLE LOCATION (STANTEC, 2010)
- GRAB SEDIMENT SAMPLE LOCATION (STANTEC, 2009)
- FLUX SAMPLING LOCATION (STANTEC, 2011-2012)

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

CLIENT:

NEWFOUNDLAND AND LABRADOR DEPARTMENT OF ENVIRONMENT AND CONSERVATION

PROJECT TITLE:

REMEDIAL OPTIONS PCB CONTAMINATED SEDIMENTS, HOPEDALE, LABRADOR

DRAWING TITLE:

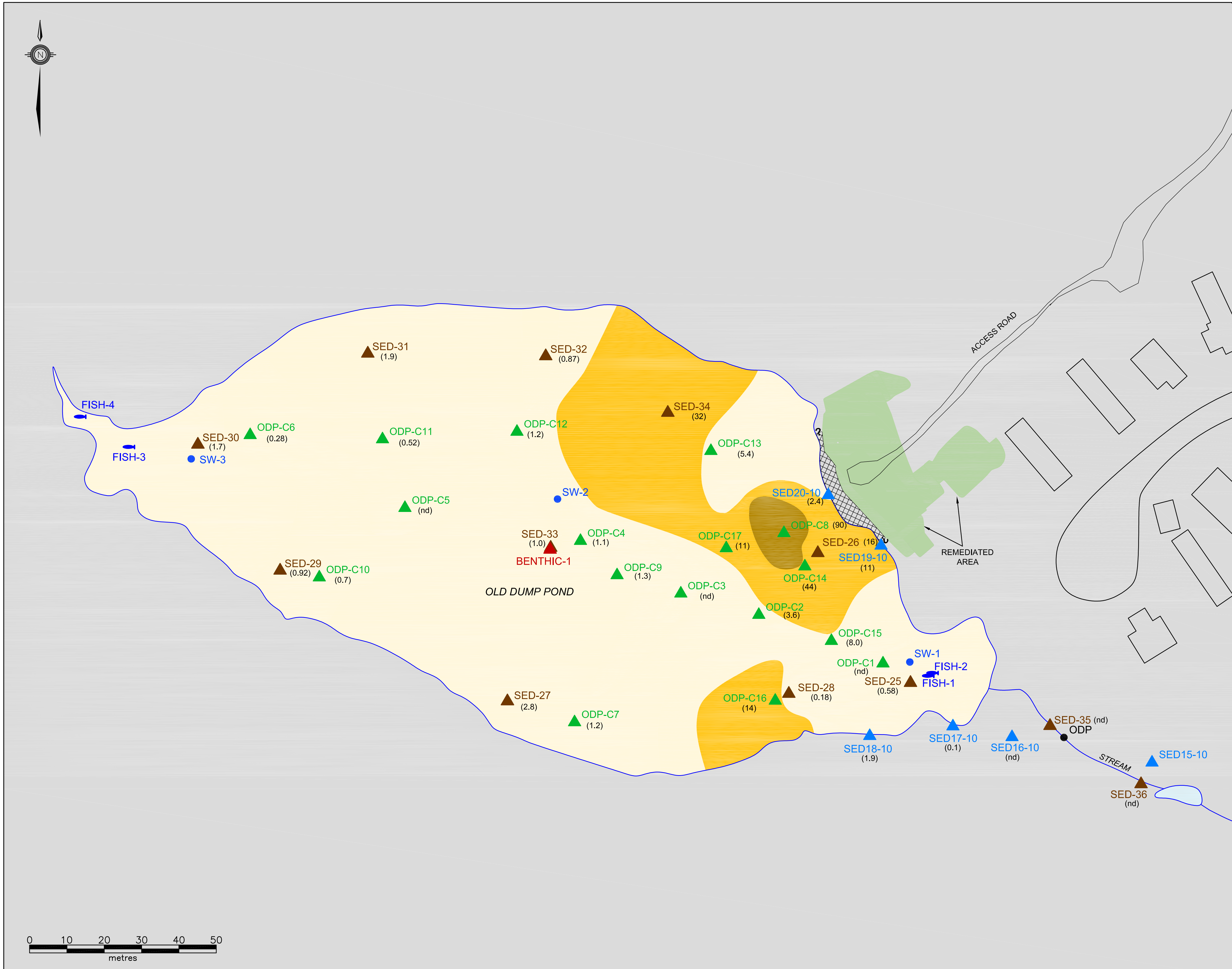
SITE PLAN - HOPEDALE HARBOUR

Stantec Consulting Ltd.

SCALE: 1:8000	DATE: MAY 30, 2014	REV. No. 0
DRAWN BY: N.M.	EDITED BY: -	CHECKED BY:
DRAWING No: 121411777.610-EE-02	CAD FILE: 121411777_610-EE-02.DWG	

Stantec

30MAY14 10:00AM



LEGEND

- GRAB SEDIMENT SAMPLE LOCATION (STANTEC, 2012)
- FLUX SAMPLING LOCATION (STANTEC, 2011-2012)
- GRAB SEDIMENT SAMPLE LOCATION (STANTEC, 2010)
- GRAB SEDIMENT SAMPLE LOCATION (STANTEC, 2009)
- BENTHIC SAMPLE (STANTEC, 2009)
- FISH LOCATION (STANTEC, 2009)
- WATER SAMPLE LOCATION (STANTEC, 2009)
- (#) PCB CONCENTRATION IN SEDIMENT (mg/kg)
- APPROXIMATE EXTENT OF PCB-IMPACTED SOIL REQUIRING REMOVAL

PCB CONCENTRATION IN SEDIMENT (mg/kg)

- < 9 (TERRESTRIAL SSTL)
- 9 - 50
- > 50

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

CLIENT:

NEWFOUNDLAND AND LABRADOR DEPARTMENT OF ENVIRONMENT AND CONSERVATION

PROJECT TITLE:

REMEDIAL OPTIONS PCB-IMPACTED SEDIMENTS, HOPEDALE, LABRADOR

DRAWING TITLE:

SITE PLAN - OLD DUMP POND

Stantec Consulting Ltd.

1:1000	DATE: JULY 14, 2014	REV. No. 0
N.M.	EDITED BY: -	CHECKED BY:
121411777.610-EE-03	CAD FILE: 121411777_610-EE-04.DWG	

Stantec

14JUL14 12:00PM

APPENDIX B

SSTL Derivation for Swimmers

Old Dump Pond

Site Specific Target Levels for Human Health (Non-carcinogenic Substances) - Old Dump Pond Swimming Toddler

Old Dump Pond - Sediment Exposure Pathways

Receptor: **Toddler** **Old Dump Pond Swimming**

$$\text{SSTL Toddler} = \frac{TDI \times SAF \times BW}{(AF_{gut} \times SIR \times ET_{ing}) + (AF_{skin} \times SDR \times ET_{derm})} + BSC$$

$$\text{HQ Toddler} = \frac{Cs \times [(AF_{gut} \times SIR \times ET_{ing}) + (AF_{skin} \times SDR \times ET_{derm})]}{TDI \times BW}$$

Compound	TDI (oral)	SAF	BSC	AF $_{gut}$	AF $_{lung}$	AF $_{skin}$	SSTL - Toddler (mg/kg)	EPC (mg/kg)	HQ (unitless)
PCBs	0.00013	0.2	0	1	N/A	0.14	1285	42.51	0.007

Time on site:

Hours per day	2
Days per Week	7
Weeks per Year	13

Parameter	Definition (units)	Default Value	Reference
TDI =	reference dose (mg/kg bw-day)	chemical specific	Bold - Health Canada (2004b), Underline - US EPA IRIS
C_S =	concentration in sediment (mg/kg)	site specific	calculated Exposure Point Concentration (EPC)
SAF =	sediment allocation factor (unitless)	chemical specific	
BW =	body weight (kg)	16.5	Health Canada (2004a) - Toddler
BSC =	background sediment concentration (mg/kg)	chemical specific	
AF_{gut} =	absorption factor for gut (unitless)	chemical specific	Assumed
AF_{skin} =	absorption factor skin (unitless)	chemical specific	Health Canada (2009)
SIR =	sediment ingestion rate (kg/day)	0.00001	Health Canada (2004a) - Toddler
SDR =	sediment dermal contact rate (kg/day) = (SA_{feet} x M_{feet}) x 1E-6 (kg/mg)	0.000043	calculated
ET_{ing} =	exposure term for sediment ingestion pathway (unitless)	0.0208	Site Specific [2 Hours per day, 7 Days per Week, 13 Weeks per Year]
ET_{derm} =	exposure term for sediment dermal contact pathway (unitless)	0.0208	Site Specific [2 Hours per day, 7 Days per Week, 13 Weeks per Year]
SA_{feet} =	skin surface area - feet (cm^2/day)	430	Richardson (1997) - Toddler - feet
M_{feet} =	sediment to skin adherence factor - feet (mg/cm^2)	0.1	Health Canada (2004a) - Toddler

Site-Specific Target Levels for Human Health (Non-Threshold Substances) - Old Dump Pond Swimming Lifetime
Site Name

Receptor: **Lifetime** **Old Dump Pond Swimming**

$$SSTL\ Lifetime = \frac{TR \times LE}{(AF_{gut} \times SIR_{adj} \times ET_{ing} \times SF_o) + (AF_{skin} \times SDR_{adj} \times ET_{derm} \times SF_o)} + BSC$$

$$ILCR\ Lifetime = \frac{C_s \times [(AF_{gut} \times SIR_{adj} \times ET_{ing} \times SF_o) + (AF_{skin} \times SDR_{adj} \times ET_{derm} \times SF_o)]}{LE}$$

Compound	SF_o (mg/kg-d)$^{-1}$	BSC (mg/kg)	AF_{gut}	AF_{lung}	AF_{skin}	SSTL - Lifetime (mg/kg)	EPC (mg/kg)	ILCR (unitless)
PCBs	2	0	1	N/A	0.14	769	42.51	5.5E-07

Time on site:		
Hours per day	2	
Days per Week	7	
Weeks per Year	13	
Years Exposed	80	Health Canada (2010)
Life Expectancy	80	Health Canada (2010)

Parameter	Definition (units)	Default Value	Reference
SF_o =	oral slope factor (mg/kg-day)$^{-1}$	chemical specific	USEPA (1997)
C_S =	concentration in sediment (mg/kg)	site specific	calculated Exposure Point Concentration (EPC)
TR =	target risk	1.00E-05	Health Canada (2010)
BSC =	background sediment concentration	chemical specific	
AF_{gut} =	absorption factor for gut (unitless)	chemical specific	Assumed
AF_{skin} =	absorption factor skin (unitless)	chemical specific	Health Canada (2010)
SIR_{adj} =	sediment ingestion rate (kg sediment-yr/kg bw-day)	5.58E-06	calculated
SDR_{adj} =	sediment dermal contact rate (kg sediment- yr/kg bw-day) = ($SA_{feet} \times M_{feet}$) x 10^{-6} (kg/mg)	1.39E-04	calculated
ET_{ing} =	exposure term for sediment ingestion pathway (unitless)	0.0208	Site Specific [2 Hours per day, 7 Days per Week, 13 Weeks per Year]
ET_{derm} =	exposure term for sediment dermal contact pathway (unitless)	0.0208	Site Specific [2 Hours per day, 7 Days per Week, 13 Weeks per Year]
$SA_{feet\ adj}$ =	skin surface area - feet (cm^2-yr/kg bw-day)	1385	Health Canada (2010) - Lifetime
M_{feet} =	sediment to skin adherence factor - feet (mg/cm^2)	0.1	Health Canada (2010) - Lifetime

APPENDIX C

Summary Tables

Table C.1 Summary Table of Various Remedial Options Hopedale Harbour

	Option 1 No Further Remediation Action	Option 2 Capping	Option 3 Dredging and Disposal
Summary of Technique	• No active remediation • Mid- or long-term monitoring and study • Consumption restriction would be required for fish catches originating from within Hopedale Harbour.	• Containment of sediments with concentrations above PELs or alternatively greater than 1 mg/kg with 0.3m thin aggregate cap; post-construction monitoring. For partial capping, a consumption restriction would be required for fish catches originating from within Hopedale Harbor.	• Removal of sediments using mechanical equipment. Disposal of PCBs in a secure confined disposal facility (CDF) (off-site); post-construction monitoring. For any removal options, a consumption restriction would be required for fish catches originating from the harbor.
Protection of human health and environment, Implementability, Compliance with policies and regulations	• Option is protective of human health provided restrictions remain on catches from the harbor (PCB sediment concentrations will remain above 0.06 mg/Kg) • Unlikely to cause significant risk to marine organisms at a population level beyond harbor.	• Option is protective of human health and marine populations provided restrictions remain on catches from the harbor (capping is unlikely to result in PCB sediment concentrations below 0.06 mg/Kg). • Capping will cause total destruction of existing bottom habitat, new communities will be reestablished over time. However, DFO may not authorize complete capping option with aggregate as it may change the existing marine communities permanently. Capping of all areas <1 mg/Kg would also require very large volumes of rock to be quarried and crushed and is not deemed technically feasible; capping all areas is unlikely to get regulatory approval; capping partial areas may receive authorization and be technically implementable. • Placement of geosynthetic membrane may be required if sand base layer cannot support weight; geosynthetic membrane placement is a complex technology and may be impractical to do; detailed harbor current information will be required to evaluate suitability.	• Option is partially protective of human health and marine populations, however, residual concentrations are not expected to drop below 0.06 mg/Kg (fishing restrictions will be required for harbor). Dredging will cause total removal of existing benthic community, new benthic community will be reestablished over time depending on size of area removed. • All dredging methods are likely to have post-dredge PCB residuals above 0.06 mg/Kg caused by technological limitations for positioning and re-suspension/re-deposition. Hydrographic modeling may also clarify the potential for clean areas to be recontaminated due to currents moving PCB sediment from adjacent areas (partial removal option). • Alternative involving on-site CDF deemed not feasible due to limited space to actually construct (many hectares in size). • Alternative for creation of a cell by isolating a harbor bay will cause permanent habitat destruction and may require permits. A significantly large amount of locally derived crushed rock would need to be used to complete the CDF which may significantly alter the local landscape. Stability of underlying marine sediment for CDF enclosure berms may not be suitable. • Alternative involving marine-based underwater cell is relatively new in Canada and may not gain regulatory approval for this situation. Method would destroy existing habitat of Hopedale Harbor, and further destroy a clean site selected for receiving and capping dredge material. Although technically implementable, only partially meets regulatory requirements as it may be rejected by DFO based on habitat destruction implications. Approach partially meets threshold criteria.

	Option 1 No Further Remediation Action	Option 2 Capping	Option 3 Dredging and Disposal
Long-term Effectiveness: Reduction in Risk to Human Health and Environment Compared to Existing Conditions	• No adverse human health effects providing fishing restrictions remain. • It is considered unlikely that there will be significant effects to marine organisms within the Harbor at a population level, although no formal assessment of risk to ecological receptors has been performed at the present time. • Monitoring required • A consumption restriction would be required for fish catches originating from harbor area.	• Adverse human health effects for full or partial capping option likely as sediment concentrations may not stay below 0.06 mg/Kg due to resuspension, long-term recontamination from adjacent impacted (uncapped) areas, and bioturbation effects. Consumption restrictions may be required for harbor. • PCBs beyond cap (partial cap alternative) are not predicted to migrate. Monitoring will be required to confirm. • It is considered unlikely that there will be significant effects to marine organisms within the Harbor at a population level, although no formal assessment of risk to ecological receptors has been performed at the present time. • Objective of containing sediments that cause adverse effects to benthic biota met, however complete removal of biota is caused by construction, with new (and possibly different) benthic community reestablished over time.	• Some adverse human health effects for full or partial removal. Residual risks remain in harbor as residual concentrations are not expected to be below 0.06 mg/Kg. • A consumption restriction would be required for fish catches originating from Hopedale harbor under any removal alternative. • Residual sediments with PCBs remaining in harbor not predicted to migrate to outer harbor. Monitoring required • It is considered unlikely that there will be significant effects to marine organisms within the Harbor at a population level, although no formal assessment of risk to ecological receptors has been performed at the present time. • Objective of removing sediments that cause adverse effects to benthic biota met, however complete removal of biota is caused by construction, with new benthic community reestablished over time. • Some very small increased risk to humans from exposure to PCB material during the dewatering and transportation work.
Reduction of Toxicity/volume/ mobility, Short -term Effectiveness of Technique	• No reduction in contaminant volume. Ongoing studies will reduce the uncertainty regarding effects of PCB movement (flux) from the harbor and marine organisms. • Migration of impacted sediments from harbor to outer harbor is predicted to be very low.	• No reduction in contaminant volume. Toxicity of underlying sediments will not change. • May result in spread of PCB during construction (cap material causes some displacement/resuspension of impacted sediment). • Capping the >1 mg/Kg zone not designed for full containment of contaminants (to allow unrestricted fishing). Migration of remnant sediments from harbor to outer harbor is predicted to remain very low. • Capping is demonstrated permanent technology that could be completed in several construction seasons, but adverse weather conditions during construction will result in costly downtime. • Size of area could result in project extending over several seasons. • Monitoring and possible maintenance required. • A consumption restriction would be required for fish catches originating from within Hopedale Harbor for the partial capping option.	• Permanent reduction in contaminant volume and toxicity. However, removal will not completely remove the overall Harbor impacts; residual potential for PCB bioaccumulation is expected to remain. • Dredging is a demonstrated technology that can be completed over several construction seasons, but adverse weather conditions will result in costly downtime. • For rotary auger dredges, transportation of contaminated water volumes of this magnitude and subsequent dewatering make removal of all sediment <1 mg/Kg impractical as treatment effectiveness at this scale would be limited (discharge water would basically require non-detectable concentrations). • Clam-type dredges (CableArm) designed for contaminated sediment dredging are the most likely applicable technology. Technology generates significantly less water and may be treatable on ship-board systems prior to release. This equipment type has been used effectively around the world. • Significant reduction in contaminant volume, although not designed for removal of all PCB material. • Short-term monitoring required, no maintenance required • A consumption restriction would be required for fish catches originating from within Hopedale Harbor following dredging.

	Option 1 No Further Remediation Action	Option 2 Capping	Option 3 Dredging and Disposal
Other Considerations (stakeholder acceptance, perception and socio-economic issues)	• Option has not been vetted through community consultation	• Option not fully vetted through community consultation or with DFO. .	• Option not fully vetted through community consultation or with DFO.
Order of Magnitude Cost	$0	Partial Capping (>1 mg/Kg to >0.5 mg/Kg): $6 to $41 million Capping areas >PEL: $351 million	Partial Removal (>2 mg/Kg to >0.5 mg/Kg): $7 to $58 million Removing areas >PEL: $430 million
Annual Costs	~$100,000/yr (assumes one monitoring per year). Frequency may be adjusted based on initial data trends following five years of study.	~$100,000/yr (one annual monitoring event, maintenance may be required if cap damaged). Frequency may be adjusted based on initial data trends following five years of study.	~$100,000/yr (one annual monitoring event). Frequency may be adjusted based on initial data trends following five years of study.

Table C.2 Harbour Screening Matrix

		Option 1	Option 2		Option 3					
	Metric	**No Further Action, Monitoring, Institutional Controls**	**Alternative 2a Capping All Sediments above PEL's**	**Alternative 2b Partial Capping of PCB >1 ppm**	**Alternative 3a(i) Removal of PCB >CCME PELs, On-site Containment**	**Alternative 3a(ii) Removal of PCB >1 ppm, On-site Containment**	**Alternative 3b(i) Removal of PCB >CCME PELs, Underwater Containment**	**Alternative 3b(ii) Removal of PCB >1ppm, Underwater Containment**	**Alternative 3c(i) Removal of PCB >CCME PELs, Disposal Off-site**	**Alternative 3c(ii) Removal of PCB >1 ppm Disposal Off-Site**
Threshold	Overall Protection of Human Health and the Environment	P (note 3)	N	P	P	P	N	P	P	P
	Technically Implimentable	Y	N	Y	N	N	P, R	P, R	Y (Note 2)	Y
	Compliance with Applicable or Relevant and Appropriate Requireme	Y	Y	Y	Y	P	Y	Y	Y	Y
	Long-term Effectiveness and Permanence	Y	Y	Y (note 1)	Y	Y	Y (note 1)	Y	Y (note 1)	Y
Balancing	Reduction of Toxicity, Mobility, or Volume through Treatment	P (note 1)	Y	P (note 1)	Y	P (note 1)	Y	P (note 1)	Y	P (note 1)
	Short-term Effectiveness	Y	Y	Y (note 1)	Y	Y (note 1)	Y	Y (note 1)	Y	Y (note 1)
	Cost	Y	N	Y	N	Y	N	Y	N	Y
	Government Acceptance	Y	Y	Y	Y	Y	R	R	Y	Y
Option to move Forward for further consideration		**Y**	**N**	**Y**	**N**	**N**	**N**	**Y**	**N**	**Y**

Y Fully Meets Criteria
P Partially Meets Criteria
N Does not meet criteria
R Requires further consultation

Notes:

1 Hydrographic studies currently demonstrated stability and permenance of the exisiting PCB distribution in sediments. Requires long-term monitoring to confirm assumptions of risk assessment.

2 Implementation will require many years to complete owing to the short construction seasons.

3 Possible localized effects on harbor marine organisms, but not significant at a population level beyond harbor; sediments determined to have limited mobility