BASELINE ASSESSMENT OF CONTAMINANTS IN SEDIMENTS AND MARINE BIOTA OF NORTHUMBERLAND STRAIT, NOVA SCOTIA, CANADA

by

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ABSTRACT

A bleached kraft pulp mill operating in Pictou County, Nova Scotia has discharged effluent into former tidal estuary known as Boat Harbour since 1967. After treatment in Boat Harbour, effluent is discharged into Northumberland Strait. Effluents will no longer be discharged after January 31, 2020 and remediation will start thereafter. A previous review of historical documents to identify contaminants in marine biota of Northumberland Strait found that data was insufficient to properly evaluate the baseline conditions prior to remediation. This study evaluated concentration of metals, dioxins and furans and methyl mercury in surficial sediments and marine biota (*i.e*. American lobster (*Homarus americanus*), rock crabs (*Cancer irroratus*), and blue mussels (*Mytilus edulis*) of Northumberland Strait. Results were compared to Canadian Council of Minsters of Environment and Canadian Food Inspection Agency guidelines showed limited contamination signature in sediments and marine biota of Northumberland Strait. Recommendations to have long-term monitoring is provided for remediation.

LIST OF ABBREVIATIONS USED

2,3,7,8 - TCDD- 2,3,7,8-tetrachlorodibenzo-p-dioxin
2,3,7,8 - TCDF- 2,3,7,8-tetrachlorodibenzofuran
As - Arsenic
AOX - Absorbable Organic Halide
BH - Boat Harbour
BHTF - Boat Harbour Treatment Facility
BOD - Biochemical Oxygen Demand
BCR - Bureau of Reference
CCME - Canadian Council of Ministers of Environment
Cd - Cadmium
CEPA - Canadian Environmental Protection Agency
CFIA - Canadian Food Inspection Agency
COD - Chemical Oxygen Demand
Cr - Chromium
Cu - Copper
D/F - Dioxin and Furan
DFO - Department of Fisheries and Oceans
DL - Detection Limit
DGT - Diffusive Gradient in Thin Films
EEM - Environmental Effects Monitoring
ERL - Effects Range Low
ERM - Effects Range Median
FA – Fisheries Act
Hg - Mercury
ISQG - Interim Sediment Quality Guideline
MeHg - Methyl Mercury
MFS- 3-Mercaptopropyl-Functionalized Silica
N - North
NE - North East
NS – Northumberland Strait
NOAA - National Oceanic and Atmospheric Administration
Pb - Lead
PCDD - Polychlorinated Dibenzodioxins
PCDD - Polychlorinated Dibenzofurans
PEL - Probable Effects Level
PPI - Pulp and Paper Industry
PPER - Pulp and Paper Effluents Regulation
PLFN - Pictou Landing First Nation
POP - Persistent Organic Pollutants
SQGs - Sediment Quality Guidelines
TSS - Total Suspended Solids

TOC - Total Organic Carbon
TEF - Toxic Equivalency Factor
TEQ - Toxic Equivalency
VOC - Volatile Organic Compound
VSC - Volatile Sulphur Compound
USEPA - United States Environmental Protection Agency
Zn - Zinc

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CHAPTER 1 - INTRODUCTION

1.1 Industrial Effluents and Environmental Effects

Industrial wastewater effluents are major sources of contamination for aquatic environments via regulated and unregulated discharges (Ali and Sreekrishnan, 2001; Chaudhary and Walker, 2019). A major threat to aquatic ecosystems is untreated or partially treated industrial wastewater discharges to aquatic receiving environments (Singh and Chandra, 2019). The pulp and paper industry (PPI) are a major industry contributing to environmental pollution after oil, cement, leather, textile, and steel industries (Ali and Sreekrishnan, 2001). It is the world's sixth most polluting industry, discharging a variety of atmospheric, liquid, and solid waste pollutants into the environment (Ugurlu et al., 2008). The PPI has been expanding in South America but started declining in the beginning of 2000 in North America with widespread mill closures (Bogdanski, 2014). However, despite increasing trends of switching from print to electronic media, increasing market demands for paper products continue within North America, Asia, and Europe collectively consuming 90% of global paper production (Szabo et al., 2009). Canada is the world's largest exporter of pulp and newsprint thus; the PPI remains a fundamental pillar of the economy and natural resource sector (Environment Canada, 2013). However, effluents from paper and pulp mills can be highly toxic and are a major contributor to aquatic pollution. More than 250 chemicals have been identified in effluents derived from different stages of paper production. PPI also generates large volumes of wastewater for each metric ton of paper produced depending on the raw material and process being used (Ali and Sreekrishnan, 2001; Kamali and Khodaparast, 2015).

Pulping, the separation of cellulose and hemicellulose wood fibers from lignin, can be achieved by either mechanical and chemical processes (Ali and Sreekrishnan, 2001). In the mechanical process, force is applied with minimum use of chemical to release usable wood fiber (Owens, 1991). Whereas, during chemical processes depolymerization and dissolving of lignin is done to produce purified cellulose fiber. There is 55-60% discharge of lignocellulosic waste from raw material (wood chips), while only 40-45% of pulp is obtained during the chemical pulping process. The lignocellulosic waste consists of various complexes of organic and inorganic pollutants, which if released untreated, may cause considerable damage to the receiving water (Pokhrel and Viraraghavan, 2004).

The wastewater from the PPI have a high biochemical oxygen demand (BOD), chemical oxygen demand (COD), chlorinated compounds (measured as absorbable organic halide, AOX), suspended solids, fatty acids, tannins, resin acids, lignin, and its derivatives, sulfur and sulfurous compounds (Ali and Sreekrishnan, 2001). Pollutants from PPI comprise naturally occurring wood extractives (tannins, resin acids, lignin) and xenobiotic compounds (e.g., chlorinated lignins, resin acids, and phenol, dioxins and furans).

1.2 Project Background

1.2.1 Study Site

A'se'k, "the other room" commonly known as Boat Harbour (BH) is a former tidal estuary located within Mi'kmaq Pictou Landing First Nation (PLFN) on the Northumberland Strait (NS) in Nova Scotia, Canada (Pictou Landing Native Women's Group et al., 2016). For the last 50 years, a bleached kraft pulp mill located at Abercrombie Point in Pictou County has been discharging its effluent in BH before its final discharge to NS (Fig. 1).

Fig. 1. Location of Boat Harbour in Pictou County relative to the pulp mill, communities of Pictou Landing First Nation, and the town of Pictou and final discharge point of Northumberland Strait. (Adapted from Romo et al. (2019).

Historically, BH was used by PLFN community for fishing, hunting, spiritual, and ceremonial purposes. However, in order to improve the economy of Nova Scotia in the 1960s, the provincial government offered raw water supply and BH as an effluent treatment facility to many industries including this kraft mill (Hoffman et al., 2017a). In 1967, the mill-initiated operations and began discharging its raw effluent to BH. From 1967 until present the mill has been operated by different mill owners. It was first owned and operated by Scott Paper Company. In 1996, responsibility for operating the mill was transferred to Kimberly Clark, then subsequently to Neenah Paper in 2004 and finally to Northern Pulp in 2008 which is the current owner of the mill (Dillon Consulting Limited, 2000; Pictou Landing Native Women's Group et al., 2016).

After two years of mill operation in 1969, the Boat Harbour Treatment Facility (BHTF) was constructed to treat wastewater effluents before their discharge to Northumberland Strait (Romo et al., 2019). Furthermore, in 1972 a dam was built at the estuary outlet and BH was transformed into a freshwater pond. The BHTF was also upgraded in 1972 consisting of twin settling ponds and an aerated stabilization basin. Effluent from the mill is piped beneath East River and discharged to settling ponds for sedimentation. After sedimentation, effluents flow to an aerated stabilization basin for the oxidation of wastewater. After 5-6 days of aerated treatment, effluent is then discharged to a stabilization lagoon, that is BH. Effluents remain here for 20-30 days before final discharge to the Northumberland Strait through a dammed estuary mouth (Fig.1 and Fig. 2) (Hoffman et al., 2017a). Along with mill effluents, BH also used to receive wastewater from a local chlor-alkali plant known as Canso Chemicals Ltd. which operated in the area from 1971-1992 (Seakem Oceanography Ltd., 1990; SeaTech Ltd., 1996; Andrews and Parker, 1999; St-Jean et al., 2003).

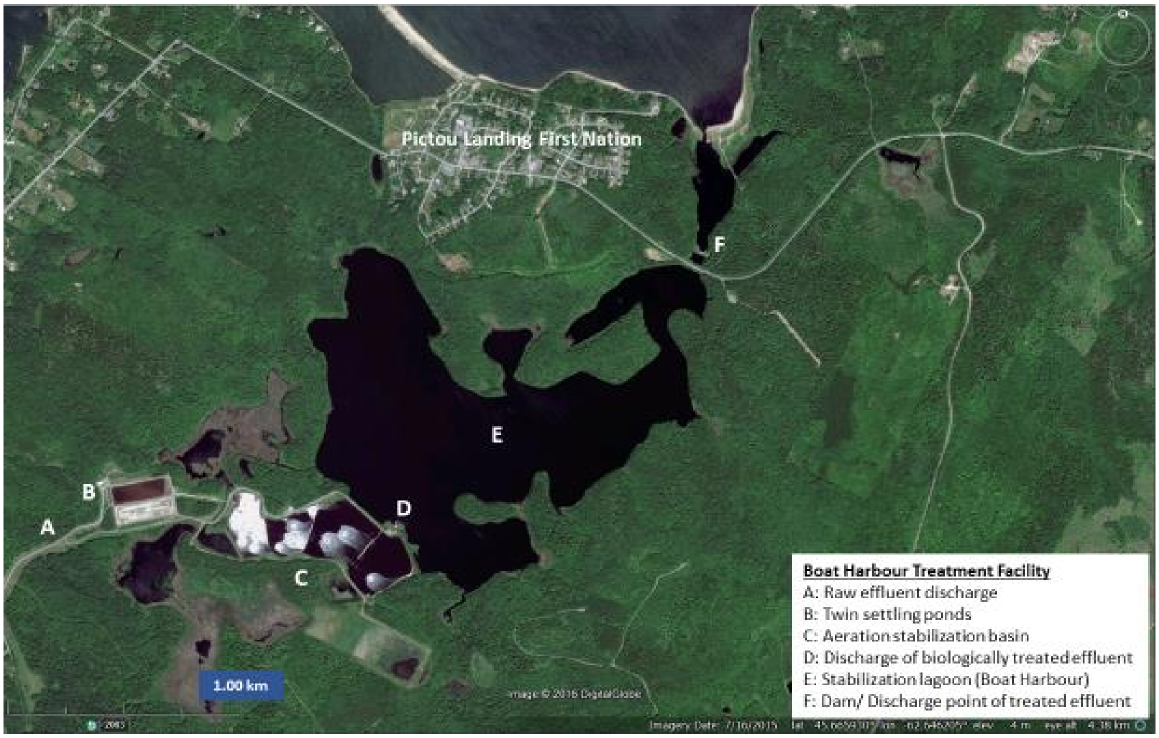

Fig. 2. Components of Boat Harbour Treatment Facility (BHTF) (from Hoffman et al. (2017a).

1.2.2 Public Concerns and *Boat Harbour Act*

Fifty-years of effluent discharge from the pulp mill and former chlor-alkali plant into BH has created large volumes of unconsolidated sediments impacted by inorganic and organic contaminants. The PLFN community (population <500) is located in the North-East direction (2 km) and the Town of Pictou (population 3500) in the North West direction (5 km) of BHTF (Fig. 1). Over the years, significant concern has been raised by both communities (Hoffman et al., 2015; Hoffman et al., 2017b). The adverse environmental impacts including poor air and water quality, soil contamination, and negative impacts on recreational activities have been the main concern of the PLFN community. Reid (1989) reported potential adverse human health effects linked to the mill and found that Pictou had significantly higher proportions of respiratory disease compared to provincial averages for three consecutive years. This research recommended an epidemiological study related to the mill should be conducted to confirm these findings (Reid, 1989). Although communities have long advocated for closure of the mill, public attention gained momentum in 2014 following an unprecedented effluent leak, and after, a broken stack precipitator (air quality equipment) (Hoffman et al., 2015). The mill was fined $225,000 CAD as the magnitude of the mill's effluent leak was found deleterious to fish under the federal *Fisheries Act* (1985) (Pictou Landing Native Women's Group et al., 2016). After years of public protest, the *Boat Harbour Act* 2015 was passed (Boat Harbour Act, 2015). According to this act, BH will be closed for effluent treatment by January 31, 2020. Remediation of contaminated sediments will begin in 2020 by the province of Nova Scotia and Nova Scotia Lands is the proponent of the remediation project. The aim of this remediation project is to return BH to its pre-tidal estuary state.

Contaminants from industries near BH have significantly impacted the environment of the area. Numerous ongoing studies have characterized the impacted wetlands, soils, and groundwater prior to remediation. According to Hoffman et al. (2017a), over the past 25 years, BH sediments metal(loid) concentrations were up to 20 times higher than samples collected from other un-impacted reference sites. Concentrations of contaminants in sediment were found to be above the Canadian Council of Ministers of Environment (CCME) Sediment Quality Guidelines (SQGs) posing a potential risk to aquatic ecosystems. Sediment mercury concentrations also exceeded CCME freshwater and marine SQGs (Hoffman et al., 2017a).

Despite numerous studies documenting effluent impacts on sediments in BH to assist remediation decisions, comparable baseline data related to contaminants in the marine environment of Northumberland Strait was lacking (Romo et al., 2019). To achieve the ultimate aim of *Boat Harbour Act* to bring BH to pre-tidal form, it is important to establish baseline data on contaminants in sediments and biota of the marine receiving environment of the Northumberland Strait. Baseline data is required to determine historical impacts and to assist future environmental effects monitoring during remediation of BH sediments, which will commence in 2020.

1.3 Research Objectives

The two main objectives of this research are to:

1) Assess levels of contamination of metals, total mercury, methyl mercury, and dioxins and furans in sediments and biota of the marine receiving environment of Northumberland Strait.

2) Prepare baseline pre-remediation data which can be used for environmental effects monitoring during and post-remediation to assess the effectiveness of remediation activities.

CHAPTER– 2 LITERATURE REVIEW

2.1 The Canadian Pulp and Paper Industry

Canada has been producing paper for 200 years and is one of the largest exporters of pulp and paper in the world since the beginning of the 20th century. The Canadian pulp and paper industry (PPI) had produced almost 10.5 million tonnes of pulp, 8.2 million tonnes of newsprint, and 6.9 tonnes of printing and writing paper in the year 2004 (Martel et al., 2005). From this production, only 17% was shipped domestically within Canada and the rest was mainly exported to the U.S., Asia, and Western Europe. These exports were worth $20.5 billion CAD which represents a 70% export intensity (Bender et al., 1981; Arntzen et al., 1995).

Furthermore, according to Natural Resources Canada, Forest Fact Book 2018-2019, Canada is still the second-largest exporter of wood pulp after Brazil with 17% of world value. It also is leading global producer and exporter of newsprint worth $1.98 billion CAD (Natural Resources Canada, 2019). This makes PPI highest in the Canadian manufacturing sector and therefore the industry remains a fundamental pillar of the economy and natural resource sector (Environment Canada, 2013). Canada accounts for almost 10% of the world's total forest coverage. Historically, it also made PPI in Canada one of the country's most vital industries in terms of value of production and total wages paid (Sinclair, 1990).

Although PPI plays an important role in generating revenue for the country, its contribution to environmental pollution cannot be ignored. It is a resource-intensive industry that uses a large amount of energy, water, and forestry resources (Murray, 1992; Toczylowska, 2017). These industries generate large volumes of wastewater for each metric ton of paper production. It has been estimated that the PPI industry is responsible for 50% all waste dumped in Canadian aquatic ecosystems (Sinclair, 1990). Effluents from PPI industries generate large amounts of toxic substances in water which may lead to zooplankton and fish mortality and negatively impact aquatic ecosystems (Hewitt et al., 2008; Singh and Chandra, 2019) They also create problems such as slime growth, thermal impacts, scum formation, and colour problems which affect the aesthetic quality of water (Pokhrel and Viraraghavan, 2004).

2.1.1 The Pulp Industry Process

To understand the nature of pollutants from the pulp industry it is necessary to review the composition of primary substrate, wood, and different processes that it must undergo to produce pulp needed for papermaking (Murray, 1992; Singh and Chandra, 2019). The pulp and paper making process consists of five steps and each step can be carried out using a variety of methods (Fig. 3). Different effluents are released during different stages of papermaking (Chandra et al., 2018).

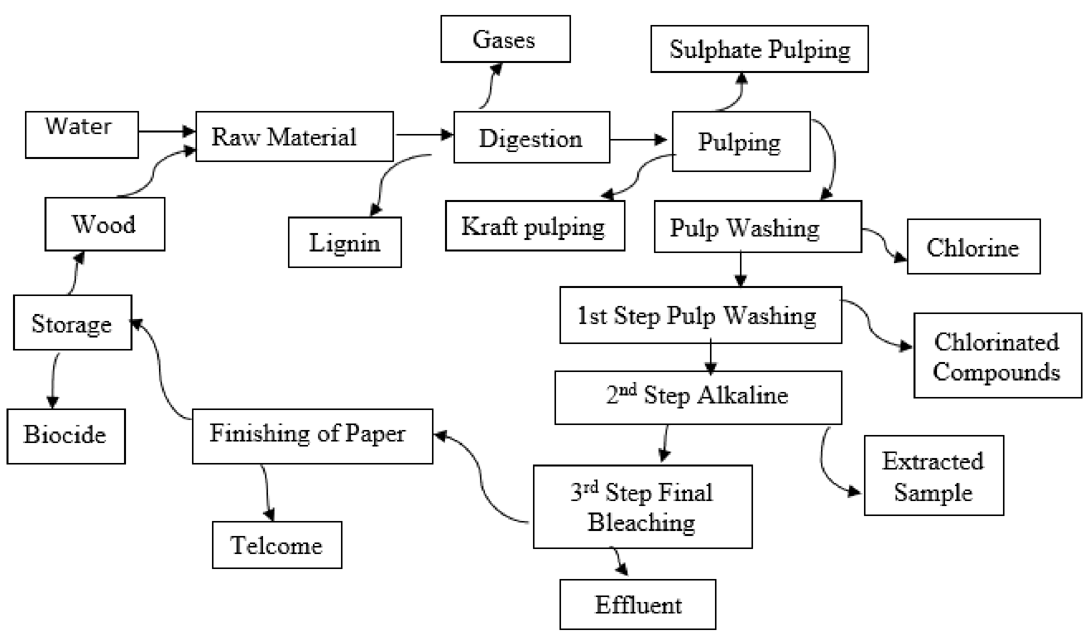

Fig. 3. Schematic illustration of a paper pulp manufacturing process (from Chandra et al., 2018).

Following are the major steps in the pulp making process:

i) Debarking (raw material preparation) - In this step, plant fiber is converted into smaller pieces called chips and removal of bark is done. The bark is removed by tumbling in large steel drums and wash water is applied (Smook, 1992). In this step, the nature of the raw material used, (i.e., hardwood, softwood, agro residues) results in the transfer of tannins and resin acids present in the bark to process waters (Ali and Sreekrishnan, 2001).

ii) Pulping – During pulping wood chips are converted into pulp. This removes most of the lignin and hemicellulose from raw material, resulting in a cellulose-rich pulp. Pulping can be done by two processes mechanical and chemical (Ali and Sreekrishnan, 2001). In the mechanical process, force is applied with minimum use of chemicals to release usable wood fiber (Owens, 1991). Whereas, during chemical processes depolymerization and dissolving of lignin are done to produce purified cellulose fiber. The chemical process can be executed in two ways that are by kraft (sulfate) and sulfite.

During the early half of the twentieth century, sulfite pulping predominated in Canada, until it was replaced by kraft pulping. Today kraft mills account for a very large share of total pulp production (Murray, 1992). The pulp mill at Abercrombie Point (discussed in Chapter-1) also uses the kraft pulping process. In the kraft pulping process, woods logs are digested at high temperatures (160-170°C) and pressure using mixture of sodium hydroxide (NaOH) and sodium sulfide (Na_2S). Whereas, in sulfite pulping mixture of sulfurous acid (H_2SO_3) and bisulfite ions (HSO_3^-) is used (Saltman, 1978). During this step, long-chain fatty acids and resins are transferred to process water.

iii) Bleaching - In this step brown pulp obtained is changed into the desired color. Several bleaching agents are used depending on the mill. The most common agents used in bleaching are chlorine, chlorine dioxide, hydrogen peroxide, oxygen, and ozone (Martin et al., 2000; Ali and Sreekrishnan, 2001). In Canada, it was estimated that 47 mills used chlorine in their bleaching process prior to 1992 (Minister of Supply and Services Canada, 1991). During this process lignin, phenols, resin acids get chlorinated and transformed into potentially toxic organochlorine compounds. Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzo-p-furans (PCDFs) are mainly produced during pulp bleaching process, where they are formed from chlorinated phenols, and particularly from chlorinated 2-phenoxyphenols (Murray, 1992).

iv) Washing- Here bleaching agents are removed from pulp by using alkali (caustic soda) and hence also known as alkali extraction stage.

v) Paper and paper products - To produce the final product, the pulp is washed with appropriate filters (clay, titanium dioxide, calcium carbonate) and resin or starch which behaves as sizing agents. After the manufacturing process wastewater is generated which contains cellulose, hemicellulose, lignin, resins, fatty acids, and other phenolic compounds. These compounds are finally washed out as black liquor (Biermann, 1996; Kincaid, 1998).

2.1.2 Contaminants of Concern

It is well known that contaminants from PPI are acute or even chronic toxins (Sunito et al., 1988; Ali and Sreekrishnan, 2001; Singh and Chandra, 2019). Contaminants released from PPI are mainly classified as gaseous pollutants, inorganic metallic, and inorganic non-metallic and organic pollutants.

i. Gaseous Pollutants

The PPI generates large quantities of atmospheric and effluents emissions which may lead to environmental degradation (Hewitt et al., 2002; Hoffman et al., 2017b). Emissions from different industries vary depending on its pulping methods, wood species, and technology used (Soskolne and Sieswerda, 2010). During the papermaking process, various volatile sulfur compounds (VSCs) and volatile organic compounds (VOCs) are produced. These VSCs and VOCs eventually lead to the production of reduced sulfur compounds including methyl mercaptan (CH_3SH), dimethyl disulfide (CH_3SSCH_3), and hydrogen sulfide (H_2S) (Higgins et al., 2006). Other gaseous compounds released in PPI are sulfur dioxide (SO_2), sodium oxide (Na_2O), chlorine (Cl_2), chlorine dioxide (ClO_2), and hydrogen peroxide (H_2O_2) (Singh and Chandra, 2019).

ii. Inorganic Metallic and Non-Metallic Pollutants

The major metals released by the PPI are arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), manganese (Mn), mercury (Hg), lead (Pb), and zinc (Zn) (Sunito et al., 1988; Ali and Sreekrishnan, 2001; Hakeem and Smita, 2010; Singh and Chandra, 2019) Out of the metals, Hg is most toxic. When it reaches to sediments via different sources it may get converted into methyl mercury (MeHg) under anaerobic conditions. Bacteria that process sulfate ($SO^{2-}{}_4$) in the environment play an important role in methylation. These bacteria take up mercury in its inorganic form and convert it to methylmercury through metabolic processes after which it enters the food chain (United States Geological Survey, 2000). When humans get exposed to MeHg, it may cause sensory and mental disturbances, visual problems, renal, pulmonary, digestive and immune problems. Furthermore, PPI also produces and releases some non-metallic compounds such as chlorine (Cl^-), sulfates (SO^{2-}), phosphates (PO^{3-}) (Chandra and Abhishek, 2011; Yadav and Chandra, 2018).

iii. Organic Pollutants

Chlorinated organic compounds such as dioxins and furans (D/F) are major contaminants of concern coming out from industrial wastewaters. They are persistent in nature and are recalcitrant to degradation and therefore known as persistent organic pollutants (POPs) (Ali and Sreekrishnan, 2001). They have been classified as 'priority pollutants' by the United States Environmental Protection Agency (USEPA, 1998), listed in Priority Substances List 1 (PSL-1) in *Canadian Environmental Protection Act* (CEPA) (Canadian Environmental Protection Act, 1999), and came into 'dirty dozen' group of POPs identified by United Nations Environment Program (UNEP, 1995).

These POPs are often toxic to aquatic species and have the potential to migrate throughout the ecosystem and ultimately accumulate in fatty tissues of a variety of organisms (Sunito et al., 1988). They have the ability to induce genetic changes in exposed organisms and thus named as 'known human carcinogens' by the World Health Organization (World Health Organization, 1997). Because of acute toxicity of two congeners of dioxins and furans, that is, 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) and 2,3,7,8 tetrachlorodibenzofuran (2,3,7,8-TCDF), discharge of these contaminants are prohibited at "measurable concentrations" according to *Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations* under the *Canadian Environmental Protection Act* (Canadian Environmental Protection Act*,* 1999). Of many pollutants from PPI, only dioxins and furans have been evaluated by Health and Welfare Canada as “priority substances” (Murray, 1992).

2.1.3 Environmental Effects Monitoring (EEM) in Canada

In the 1980s, discharges from Canadian mills were regulated federally by *Pulp and Paper Effluents Regulations* (PPER) that was passed under the *Fisheries Act* (FA) in 1971. Under this regulation, there was set daily and monthly mass-based limits for BOD and total suspended solids (TSS) and also the requirement that effluents are not acutely lethal to rainbow trout (McMaster et al., 2006; Barrett et al., 2010). Furthermore, these limits were only legal binding on mills which were constructed after the announcement of legislation in November 1971 which covered only less than 10% of mills in Canada (McMaster et al., 2006). As the regulation only covered the small part of PPI industry effluents were still high in fiber and BOD which resulted in habitat degradation and acute lethality of fish (McLeay and Associates, 1987; Folke, 1996).

Before the 1980s the regulations did not consider any dioxins and furans and organochlorine discharges, but in the late 1980s, aquatic discharges from the PPI became an area of environmental concern as dioxins and furans were found in effluents and paper products (Kringstad and Lindstrom, 1984). In early 1980s studies conducted by Sweden under the Environment Cellulose project provided the first evidence of the toxicity of effluents to fish even at very low concentrations in the receiving environment (Sandstrom et al., 1988; Sodergen, 1989).

The change in growth, biochemistry, and deformities in fish were detected in the large area of 8-10 km downstream from the pulp mill, with a dilution of the effluent by more than 1000 times (Sodergren, 1992). Along with this, some other studies were also conducted at an unbleached kraft mill which showed fewer effects compared to bleached kraft mills (Sodergren, 1992).

During the same time of these studies, Ministers of the Environment in Canada announced plans to revise the federal regulatory framework in March 1989 to address the deficiencies in the 1971 regulations. The initial studies were conducted at Jackfish Bay on Lake Superior, which received effluent from a bleached kraft mill located in Terrace Bay, Ontario, Canada. This bay received no other effluents and had no permanent human residents. The results found that fish exposed to primary treated effluents from bleached kraft mill displayed similar reproductive effects to those found in Sweden study (Munkitrick et al., 2013).

Fish exposed to pulp mill effluent showed an increased age to sexual maturation, reduced gonadal development, and expression of secondary sexual characteristics, and reductions in circulating reproductive steroid hormone levels (McMaster et al., 1991; Munkittrick et al., 1991; Oakes et al. 2005; McMaster et al., 2006). Furthermore, in mid-to-late 1980s polychlorinated dioxins and furans were detected in effluents as a by-product of chlorine bleaching (Luthe et al., 1988; Allen et al., 1989). After these studies, a worldwide public campaign by Greenpeace was started against the use of molecular chlorine. However, there was no clear evidence linking chlorinated compounds (used in bleaching pulp) to effects in fish (Thornton 1991; Amato, 1993; Carey et al., 1993).

It was documented that initial studies in Jackfish Bay were done prior to the construction of a secondary effluent treatment plant (McMaster et al., 1991; Munkittrick et al., 1991; Munkittrick et al., 2013). Therefore, in the spring of 1990 samples of spawning fish were collected again and results showed the impact remained in the population despite the implementation of secondary treatment. These results were not surprising at the time as it was assumed that persistent organochlorines are responsible for the changes seen in fish and it will take several years for these persistent compounds to level in contaminated sediments (Munkrittrick et al., 1998; Munkittrick et al. 1992; Branson et al., 1985).

Furthermore, sampling was conducted again in the fall of 1990 following a scheduled mill maintenance shutdown. Results from this sampling showed the rapid recovery of liver mixed-function oxygenase (MFO) enzymes in longnose sucker (*Catostomus catostomus*), and steroid hormone in male white sucker (*Catostomus commersoni*) (Munkittrick et al., 1992). These results suggested that contaminated sediments were not a large contributor to responses at Jackfish Bay, chemical impacts were short-lived, the compounds responsible for biochemical changes were present in the secondary effluent, and if the responsible compounds were identified and removed, recovery of fish populations might take place quickly (Munkittrick et al., 1998).

After the intense public pressure globally and within Canada, new regulations for pulp and paper mills in Canada were developed in the early 1990s and were implemented in May 1992 (Munkittrick et al., 1998; Munkittrick et al., 2013). PPER was passed under the *Canadian Environmental Protection Act* in 1992 to control the release of polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). The existing PPER under *Fisheries Act* were also updated with strict limits on BOD and TSS while maintaining the similar non acute lethality requirement as in the 1971 regulations.

Unlike the earlier requirements, this regulation became the legal binding to all the mills across Canada (McMaster et al., 2006). Additionally, while re-analyzing the PPER, regulators realized that uniform limits for a few parameters in the effluent may not necessarily protect the health of all aquatic receiving bodies across Canada (Walker et al., 2002). In order to address these issues, environmental effects monitoring is included in new regulations which are the requirement at all mill's sites (McMaster et al., 2006).

2.1.4 Environmental Effects Monitoring (EEM)- *Pulp and Paper Effluent Regulations, 1992*

EEM is a science-based tool that can detect and assess the changes in aquatic ecosystems potentially affected by pulp mill effluent discharges. EEM is a repetitive system of monitoring and interpretation phases that can be used to measure the effectiveness of environmental management measure to protect the ecosystem (Walker et al., 2002). It is an assessment tool used to help determine the sustainability of human activities on ecosystem health. EEM goes beyond end-of-pipe measurement of chemicals in effluent to analyze the effectiveness of environmental protection measures (Environment Canada, 2010; McMaster et al., 2006).

In EEM, long-term effects are measured using regular cyclical monitoring and interpretation phases designed to assess and investigate the impacts on the same parameters and locations. This helps in the spatial and temporal characterization of potential effects to assess changes in receiving environments (Environment Canada, 2010).

The pulp and paper program are structured into a defined cycle, such that a mill must conduct an EEM study once every three years (Walker et al., 2002). The first cycle conducted in this program was aimed to provide baseline data for future cycles to compare against and determine components required for subsequent EEM programs. The typical EEM for PPI consists of some or all the following components: an adult fish population survey, a benthic invertebrate community survey, a study of dioxins and furans in fish tissues, a tainting study, effluent toxicity testing, and an assessment of water and sediment with their specific purpose (Table. 1).

Table 1. Required monitoring components for pulp and paper EEM programs (Adapted from Walker et al., 2002).

PPER	**Purpose**
Fish survey	Indicator of fish population
Benthic invertebrate community survey	Indicator of effects on fish habitat
Fish tissue analysis for dioxins and furans, for mills using chlorine bleaching	Indicator of effects on the usability of fisheries resources by humans
Supporting Environmental measurements • Water quality • Sediment variables	Interpretation and assessment of cause-effect linkages Interpretation of benthic invertebrate data
Sublethal Toxicity Testing • Fish • Invertebrate • Algae	Examine sublethal changes in effluent quality

2.2 Impacts of Industrial Effluents on Sediments

2.2.1 Importance of Estuaries

Coastal zones, including estuaries and bays, are the regions of active land-sea interaction. Estuaries are one of the most productive ecosystems on earth (Maanan et al., 2015). They are defined as the water bodies that connect land and ocean and extend from fully marine conditions to the effective limit of tidal influence, and where seawater is diluted by freshwater inflow (Hobbie, 2000).

Estuaries provide a number of ecosystem services such as fisheries, climate regulations, coastal protection, and waste treatment (Millennium Ecosystem Assessment, 2005; De Souza et al., 2016). Estuaries also serve as habitat for a high diversity of species for the whole or part of their life cycle and are characterized by high biological productivity (Kennish, 1991; Spencer et al., 2006). By virtue of their nature and position between marine and terrestrial environments, estuaries are the hub of variety of human activities and have become sites of major industrial developments (Ridgway and Shimmield, 2002). The disposal of waste from industries makes estuaries the ultimate receptacle of pollutants and has led to a significant increase in metal contamination.

2.2.2 Estuary Sediments as Sink and Source of Contaminants

Estuaries sediment contamination is a major source of ecosystem health stress and thus getting increasing attention from the scientific community (Riba et al., 2002; Ganugapenta et al., 2018). According to Forstner and Wittmann (1979), the world's six most heavily polluted aquatic environments by metals are estuaries. In countries with long historic industrialization such as United Kingdom, Germany, and the Netherlands, thousands of tons of metals were deposited in the estuaries and coastal areas (Forstner and Wittmann, 1979).

Limited freshwater inputs in such enclosed and semi-enclosed ecosystems, may cause enhanced accumulation of pollutants leading to potential threats to the ecosystem (Hahladakis et al., 2013; Qiu, 2015). Estuaries have also been used for dilution and disposal of waste which contributes to their deterioration. Metals and other contaminants like dioxins and furans, as well as total mercury, are gradually being concentrated in these water bodies and, at higher concentrations, they have proven toxic to marine biota and ultimately to humans (Maanan, 2008).

Sediments in estuaries are complex systems affected by the interaction of geological, hydrological, physiochemical, and biological factors and thus may act as a reservoir for heavy metals discharged into the marine environment (Fujito et al., 2014; Machado et al., 2016). They have a large capacity to retain heavy metals from various sources and thus act as a sink for contaminants from different industrial discharges (Gibbs, 1977; Menon et al., 1998; Barcena et al., 2017).Metals are deposited within sediments and sorb to organic-rich fine-grained particulate matter or incorporate in inorganic matter compounds when they enter marine environment (Jamshidi and Bastami, 2016; Zhang et al., 2019).

There are certain properties of sediments such as texture, pH, Eh, organic matter, salinity, sulfide contents, iron (Fe), aluminum (Al), and others which can influence biogeochemical behavior and mobility of metals in aquatic systems (Zhuang and Gao, 2014; Cipullo et al., 2018). It is very important to identify these processes in order to identify the key contaminants and sediment characteristics that can affect the bioavailability and toxicity of metals (Vezzone et al., 2019).

Under certain physiochemical conditions (current, pH, DO, redox potentials, and temperature changes), heavy metals trapped in sediments may migrate upward to the sediment-water interface. For example, if there is a decrease in redox at the interface between solid and liquid phases it would accelerate reductive dissolution of iron (Fe) and manganese (Mn) oxides which leads to the release of metals bound to them (Mukwaturi and Lin, 2015; Gao et al., 2018). In case of low pH, negative surface charges of sediment particles and Fe and Al oxides reduces, which promotes the mobility and bioavailability of metals which are co-precipitated with carbonates and sulfides (Du Laing et al., 2009).

When these metals are released to dissolved phase from sediments, bioavailability is increased leading to threats to aquatic organisms (Zhao et al., 2013; Dhanakumar et al., 2015; Machado et al., 2016; Chen et al., 2016). Therefore, sediments are not only sink for many pollutants but can also be the sources of pollutants. Furthermore, the release of metals in sediments depends on their different chemical forms, which shows different physical and chemical behaviours in terms of chemical interaction, potential toxicity, bioavailability and mobility (Sun et al., 2016; Gabarron et al., 2017; Kang et al., 2017; Liu et al., 2018).

Bioavailability is an important factor in metal toxicity assessment. It is defined as the metal fraction available for organisms from all possible uptake sources (Morel and Hering, 1993; Campbell, 1994; Ehlers and Luthy, 2003). Bioavailable metal fraction, mainly metal ions, represents the toxic metal fraction instead of total concentrations of metals (Morel and Hering, 1993). Heavy metals are area of concern for marine organisms and their consumers due to their toxicity, persistence, and bioaccumulation (La Colla et al., 2018).

According to the European "Community Bureau of Reference" (BCR) sequential extraction procedure, chemical forms of heavy metals in sediments are divided into four parts, that is, the exchangeable, reducible, oxidizable and residual parts (Quevauviller et al., 1997). The bioavailable fraction is usually composed of the former three parts which could be released into the overlying water. Therefore, the chemical fractions of heavy metals with high bioavailability should be assessed for evaluation of ecological risk in sediments (Cheng and Yap, 2015; Kang et al., 2017; Liu et al., 2018).

2.2.3 Sediment as an Indicator of Contamination

Marine sediments represent, quantitatively, the major compartment for metal storage in aquatic environments (Chapman et al., 1998). Therefore, they act as a useful indicator of metals contamination in aquatic environments, metal toxicity and hazard in sediments (Saher and Siddiqui, 2019). Due to their trapping capacity, the evolution of metals in sediments reflect the geochemical history of the region (Barcena et al., 2017). They provide both short- and long-term memory of contaminant loading to a water body. Continuous monitoring of sediment quality is very essential in determining the state of pollution of the marine environment. Survey of metal concentrations in sediments and comparison between these concentrations and non-polluted baselines are an important step in understanding the transport and deposition of metals in the environment (Wang et al., 2012). Characterizing distribution and concentration of metal contaminants within sediments is necessary in order to quantify pollution levels (Santos et al., 2005; Walker et al., 2013a, 2013b, 2013c; Zhang et al., 2019).

There are several factors which should be considered while conducting an assessment of contaminated sediments. For instance, particle size plays an important role in controlling the pollutant concentrations in sediments. It is generally believed that metals are associated with smaller particle sizes (Whitney, 1975; Gibbs, 1977; Martincic, 1990; Biksham et al., 1991). This trend is attributed to sorption, co-precipitation, and complexing of metals on particle surface.

Smaller particles have larger surface area and therefore can potentially be associated with a higher concentration of metals (Parizanganeh, 2008). Therefore, it is important to consider the effect of particle size by using geochemical methods (Paramasivam et al., 2015).

The toxicity of contaminated sediments is usually measured by using a weight-of-evidence approach, comprising chemical, ecotoxicological, and ecological analysis (Marziali et al., 2017). In recent years different indices have been developed which can be used in estuaries for metal assessment. Each of indices aggregates the concentration of metal contaminants and can be classified as following three types (Caeiro et al., 2005):

a) *Contamination indices*- It compares the contaminants with non-polluted and/or polluted stations measured in the study area or simply aggregate metal concentrations

b) *Background enrichment indices*- It compares the results for the contaminants with different baseline levels, available in the literature, relevant for the study area.

c) *Ecological risk indices*- It compares the results for the contaminants with Sediment Quality Guidelines (SQGs) values developed by different institutions.

2.2.4 Sediment Quality Guidelines (SQGs)

SQGs are important empirical tools for the protection and conservation of marine and freshwater environments (Birch, 2018). These guidelines evaluate the extent to which the sediment-bound chemical status might adversely affect marine organisms and are designed to help in the interpretation of sediment quality (Maanan et al., 2015). Long and Morgan (1990) and MacDonald et al., (1996) outlined these SQGs and described the derivation of low- and high-level guideline values for each contaminant. United States National Oceanic and

Atmospheric Administration's (NOAA) defines effects range low (ERL) and effects range median (ERM) guideline values, which is used to measure potential risk of pollutants in sediments to the marine ecosystem. According to guidelines, if the metal concentrations are below ERL, this indicates adverse effects are rarely present. If concentrations of exceed ERMs, negative effects on benthic communities are expected with at least a 50% frequency. In the case of concentrations values greater than ERLs, but less than ERMs, chronic or acute biological effects may occur occasionally (Macdonald et al., 1996; Birch, 2018; Zhang et al., 2019; National Oceanic and Atmospheric Administration, 2019).

In Canada, the Canadian Council of Ministers of the Environment (CCME) has developed interim sediment quality guidelines (ISQGs) and probable effect levels (PELs) for the protection of marine and freshwater aquatic life. ISQGs indicates the threshold-level effects below which negative biological effects are unlikely to be observed. Similarly, PELs indicate the concentrations above which adverse biological effects are expected to be common (CCME, 2019).

2.3 Impact of Industrial Effluents on Biota

2.3.1 Importance of Benthic Invertebrates

Benthic macroinvertebrates hold an important position in aquatic food webs. They are a key component of the aquatic ecosystem as they play an important role in detritus decomposition, nutrient cycling, and energy flow to higher trophic levels (Gray and Elliot, 2009). These macroinvertebrates are either attached to or intimately linked with the benthic substrate

(Vannote et al., 1980; Rosi-Marshall and Wallace, 2002; Runck, 2007). They are the primary material exchangers across the sediment-water interface.

As benthic organisms are in direct contact with sediments, therefore levels of contamination in sediments can have a great impact on their survival (Hussain and Pandit, 2012; Maharaj and Alkins-Koo, 2007). When metal concentrations increase in the environment, it affects metal accumulation in organisms which may exceed natural levels. It may also trigger biomagnification of metals which leads to a progressive increase in chemical concentration with increasing trophic level (Luoma and Rainbow, 2008; Pinherio et al., 2012; Saher and Siddiqui, 2019).

Some metals such as Pb, Cd, Cr, and Cu can be bioconcentrated through direct uptake across the gill surface and other external body parts (Bere et al., 2016). Furthermore, ingestion of contaminated food by benthic organisms can also lead to bioaccumulation of metals in tissue of biota which may eventually biomagnify up the food chain (Chen et al., 2007; Siddique et al., 2009; Varol, 2011; Wang et al., 2012).

Bioaccumulation in organisms depends on a number of factors such as level of contamination in the environment, biotic factors such as diet and trophic position of the organism. Therefore, it reflects the amount of the elements that have been ingested, excreted, and retained. Thus, benthic invertebrates are excellent bioindicators which due to their short lifespans can provide accurate near real-time reflections of contaminant dynamics under fluctuating aquatic conditions (Stankovic et al., 2014). Bioindicators refers to any aquatic organism that can accumulate contaminants in its tissues from the surrounding environment. Therefore, a change in a bioindicator species tissue metal burden reflects varying metal concentrations in the surrounding environment (Rainbow, 1995; Al-Farsi et al., 2015).

2.3.2 Benthic Invertebrates as Bioindicators

Although total metal concentrations in sediments indicate varying degrees of metal contamination, it does not necessarily predict the toxicity of contaminants to aquatic organisms. The ecotoxicological risk induced by contaminated sediments depends on metal availability, uptake kinetics as well as the ability of organisms to assimilate them. This makes it very important to assess levels of contaminants in aquatic organisms as well as characterizing bulk sediment chemistry (Amiard et al., 2007; Campana et al., 2012). Different species have different sensitivities to chemical stress; therefore, it is recommended to use combination of species from different organizational and trophic levels for better understanding of sediment ecotoxicity (Maltby et al., 2005; Tuikka et al., 2011). Organisms used as metal pollution bioindicators must meet certain criteria in order to reflect the biotic and /or abiotic levels of contamination of an environment (Hodkinson and Jackson, 2005). The following are criteria for good bioindicators:

- Ability for organisms to bioaccumulate inorganic or organic contaminants (e.g., including organisms exhibiting chronic or acute impacts from contamination accumulation).
- Bioindicator organisms must be relatively easy to collect, identify, and handle.
- Must have sufficient tissue to make chemical analysis easy and accurate.
- Life span of the organism must be long enough to reflect contaminant bioaccumulation over longer temporal periods (Stankovic et al., 2014).

Various benthic organisms are being widely used as an indicator for metal pollution in aquatic ecosystems, such as insects, polychaetes, gastropods, bivalves, and decapod crustaceans (Walker et al., 2013c; Fan et al., 2014; Duysak and Ersoy, 2014; Velez et al., 2015; Walker and Grant, 2015; Alvaro et al., 2016). Some of the most popular bioindicators for long term monitoring are bivalve molluscs, particularly oyster, mussels, and clams that have been used in the monitoring of marine water and sediments (Zhou et al., 2008; Liu et al., 2017).

Blue mussels (*Mytilus edulis*) has been widely used in monitoring of the marine environment due to their unique characteristics (Walker et al., 2013d; Walker and Macaskill, 2014). Mussels were also among the first animals used by researchers for assessing the environmental quality of seawater (Beyer et al., 2017). Blue mussels are sessile which helps in getting location-specific information. They are medium sized which provide enough tissue material for chemical analysis. They are easy to collect as they form a mussel bed in shallow waters. Mussels are also filter-feeders which makes them efficient to accumulate pollutant chemicals from water. They have limited ability to metabolize contaminants and tend to accumulate them to the levels exceeding those found in the ambient seawater, where the concentration of many contaminants in water are often below instrument detection limits (Walker and MacAskill, 2014). All these qualities of mussels make them a good fit for environmental monitoring (Beyer et al., 2017; Walker et al., 2015). Mussels are also being used in NOAA's Mussel Watch Program which was designed to monitor the status and trends of chemical contamination of U.S. coastal waters, including the Great Lakes (Kimbrough et al., 2008).

Furthermore, some decapods such as crabs and lobsters are used for measuring heavy metal contamination in surface sediments (Ololade et al., 2011). These species are ubiquitous and live in close contact with rocky substrates. They are bottom scavengers and their diet consists of organisms from different trophic levels including clams, mussels, polychaetes, and small crustaceans. Contaminants are stored in fat-rich digestive gland, the hepatopancreas (Boudet et al., 2015; Verma and Sharma, 2017). Their limited ability to metabolize contaminants in sediments makes them a suitable bioindicator for assessing the health of marine environment (Garron et al., 2005; Walker et al., 2013c). Finfish can also be bioindicators to estimate heavy metal levels in water, but their mobility makes them potentially less reflective of the local environment relative to shellfish (Zhou et al., 2018). There are certain known factors which can influence the metal accumulation in these organisms which includes metal bioavailability, season of sampling, hydrodynamics of the environment, size, sex, changes in tissue composition and reproductive cycle (Szefer et al., 2004; El Nemr et al., 2016).

2.4 Human Health Implications of Metals in Aquatic Biota

Humans can be exposed to metals via the ingestion of aquatic biota. The elements of highest concern from a human health perspective are: As, Cd, Co, Cr, Cu, Hg, Mn, Fe, Zn, Ni, and Pb which are commonly present in effluents from different industries (Rai and Pal, 2002; Lavery et al., 2009). Heavy metals in the tissues of marine organisms may transfer to humans through aquatic organism consumption. Seafood consumption, in particular, is increasing rapidly due to their beneficial nutritional values (Guerin et al., 2011). Marine organisms such as mollusks, crustaceans, and fish contain essential amino acids for humans and are a great source of minerals, vitamins, and polyunsaturated fatty acids (Raknuzzaman et al., 2016). Therefore, it is important to monitor environmental contaminants in marine organisms, as increasing seafood consumption can result in potential health risks for humans, particularly in coastal communities who rely on seafood as their primary source of animal protein (Chien et al., 2002; Raknuzzaman et al., 2016).

2.5 Importance of Baseline Data

Canada has an abundance of aquatic resources, including nearly 20% of the world's freshwater and a land mass bordering three oceans. In this era of industrialization, robust aquatic monitoring is required to protect these ecosystems from any harmful damage (Kilgour et al., 2007; Roach and Walker, 2017). Aquatic monitoring programs are designed to identify any potential environmental effects through biological, chemical, and physical changes and analyze the degree of harmful effects (Servos, 1996; Kilgour et al., 2007). For any successful monitoring program, obtaining accurate and precise baseline data is very important and a critical precondition for remediating any contaminated site (Jain, 2015). It can provide perspective on the appropriateness of remedial objectives that are derived for an impacted area. As it represents the current condition of the site before remediation, baseline data can help the managers of the project to plan remediation strategies according to site-specific conditions (Wills et al., 2003).

In Canada, monitoring comes in different forms which may include fish surveys, toxicology testing, benthic invertebrate surveys, and water quality measurements (Walker et al., 2013a, b; Walker and MacAskill, 2014; Roach and Walker, 2017). There are different federally mandated EEM programs used to measure impacts of industrial effluents such as pulp and paper (as discussed above) and metal mining effluents on receiving waters.

2.6. Gaps and Inconsistencies in Marine Biota Data from Estuary and Northumberland Strait

As per the *Boat Harbour Act* (2015) (as discussed in chapter 1), the remediation of Boat Harbour will commence after January 31, 2020. For this purpose, there is a need for current pre-remediation baseline data which can be used for comparing the effectiveness of remediation program during and post remediation. Romo et al. (2019) reviewed >200 government reports and peer-reviewed articles for relevant marine/aquatic biota data from Boat Harbour, Pictou Harbour, Northumberland Strait or reference locations. The aim of the study was to assess historical qualitative and quantitative contaminant data in marine biota (e.g., blue mussels, American lobster, and rock crabs) (Romo et al., 2019). This data was reviewed and consolidated so it could be used to help inform future monitoring for the Boat Harbour remediation project to compare against. These historical data would be useful for baseline (pre-remediation) monitoring data to be compared against, along with environmental monitoring conducted during and post-remediation.

In this study it was found there are significant gaps and inconsistencies in marine biota data. EEM became mandatory in 1992, and there are reports available only for four EEM cycles (JWEL, 1996; Stantec, 2004; Ecometrix Inc., 2007; Ecometrix Inc., 2016). As the second, fifth and sixth EEM cycle data were unavailable, second cycle results were summarized in subsequent reports using data derived from Andrews and Parker (1999) and fifth and sixth cycle results were inferred from the seventh cycle (Romo et al., 2019).

In the available reports, there were lots of inconsistencies between different cycles, which reflected differing regulatory and technical requirements for the different cycles. For instance, to assess impacts on fish and shellfish, the first cycle chose winter flounder (*Pseudopleuronectes americanus*) and rock crab for analyzing resin and fatty acids and contrasting morphological characteristics with reference samples from Merigomish Harbour (Fig. 4) (Romo et al., 2019). Blue mussels were analyzed for 10 dioxins and furans congeners, with reference sites from Caribou Island (JWEL, 1996). In contrast, the third cycle analyzed blue mussel and mummichog (*Fundulus heteroclitus)* for immunological and morphological endpoints relative to reference sites from Merigomish Harbour and Logan's Point (Fig. 4).

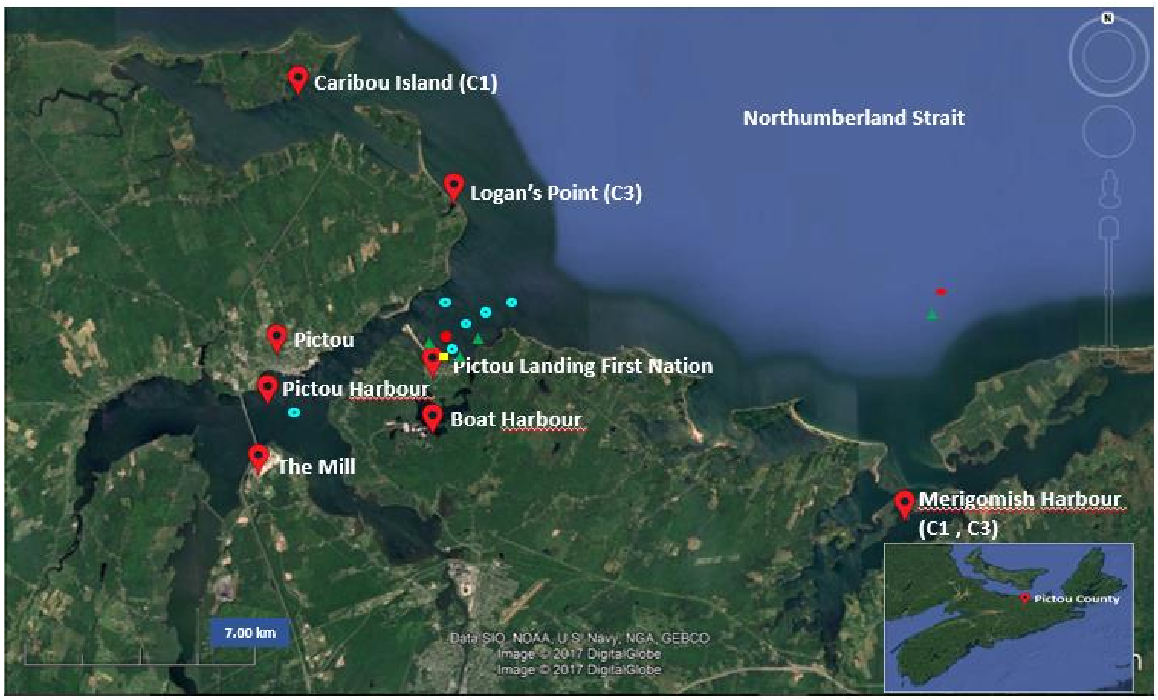

Fig. 4. Location of Boat Harbour in Pictou County, Nova Scotia. Blue circles represent blue mussel (*Mytilus edulis*) sampling locations, green triangles represent rock crab (*Cancer irroratus*) sampling locations, red circles represent American lobster (*Homarus americanus*) sampling locations and yellow squares represent soft shell clams (*Mya arenaria*) sampling locations. C1, C2 and C3 represent reference locations used in EEM cycles 1, 2 and 3, respectively (from Romo et al., 2019).

Taint testing in cycle one (JWEL, 1996), used LEM Laboratory (1994) data, but taint testing was omitted from subsequent cycles, due to a lack of significant effects. All available EEM reports noted limited impacts on marine biota (Fig.4).

In addition, despite the presence of a former chlor-alkali facility, which operated for 20 years (1972-1992) and discharged effluent into Boat Harbour, Hg has never been analyzed in the marine environment, nor Me-Hg which is susceptible to bioaccumulation. Furthermore, two dioxins and furans congeners (2,3,7,8- TCDD and 2,3,7,8-TCDF) were not analyzed in the first EEM cycle, despite claims to the contrary (Romo et al., 2019). Overall, there was a marked lack of consistency in analyses, sentinel species used across different cycles, and limited georeferenced sites, making it difficult to use this data for future reference.

To help develop useful baseline data for remediation programs, selection of suitable biota, consistency in analysis of different contaminants, and periodic monitoring are all important components (Romo et al., 2019). To establish robust baseline data, it was important to assess current conditions of the estuary and the marine environment which can be used as a benchmark during and after remediation. In order to fill this baseline data gap described in Chapter 1, the objective of this thesis is to assess the level of contamination of metals and dioxin and furans in sediments and biota of the Northumberland Strait.

Chapter-3 Assessment of historical and current baseline contaminants in sediments and marine biota near an industrial effluent discharge in Northumberland Strait, Nova Scotia, Canada

3.1 Introduction

For decades, the pulp and paper industry (PPI) in Canada has been responsible for generating large volumes of effluent wastewater. Pulp mill effluents contain organic (e.g., dioxins and furans) and inorganic contaminants including metals which can have detrimental impacts on aquatic ecosystem health (Sunito et al., 1988; Colodey and Wells, 1992; Hoffman et al., 2019). These mills generate large volumes of wastewater for each metric ton of paper produced. More than 250 chemical contaminants have been identified in effluents produced during different stages of the pulping process (Pokhrel and Viraraghavan, 2004). Wastewater from the PPI has a high biochemical oxygen demand (BOD), chemical oxygen demand (COD), chlorinated compounds, metals, suspended solids, fatty acids, tannins, resin acids, lignin, and its derivatives, sulfur and sulfur compounds (Ali and Sreekrishnan, 2001). The pulping process can employ either mechanical or kraft pulping. In mechanical pulping, force is used to generate heat and torsional forces to isolate wood fibres with limited use of chemicals, whereas kraft pulping uses sulfate or sulfite to chemically degrade lignin to isolate cellulose and hemicellulose fibres.

A bleached kraft pulp mill in Pictou County, Nova Scotia has been discharging wastewater effluent into Boat Harbour and subsequently into the Northumberland Strait since 1967 (Hoffman et al., 2017a, 2019) (Fig. 5). Prior to 1967, A'se'k, a waterbody commonly known as Boat Harbour (BH) is a former tidal estuary connected to the Northumberland Strait. Boat

Harbour lies within the Mi'kmaq Pictou Landing First Nation (PLFN) and was traditionally used by the community for hunting, fishing, and ceremonial purposes (Fig. 5).

Fig. 5. Location of Boat Harbour in Pictou County relative to the pulp mill, communities of Pictou Landing First Nation, and the town of Pictou and final discharge point into the Northumberland Strait. (Adapted from Romo et al. (2019).

In 1969, the Boat Harbour Treatment Facility (BHTF) was built and operated by the province to treat wastewater effluent from the mill and a nearby chlor-alkali plant owned by Canso Chemicals Ltd. which operated from 1972 to 1992. Further, in 1972 a dam was built at the BH outlet preventing seawater incursion while transforming BH into a freshwater pond. Canso Chemicals Ltd. operated the chlor-alkali electrolysis facility that generated sodium hydroxide and chlorine (used in the kraft pulp mill bleaching process) as well as hydrogen using mercury cell process and brine solution. The mill has undergone several owners and process changes since 1967 (Hoffman et al., 2017a; 2019).

Currently, the mill is operated by Northern Pulp and the use of elemental chlorine previously used in the bleaching process by previous owners was changed to chlorine dioxide in 1997 to meet new federal *Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations* (Northern Pulp, 2019). Effluent from the mill (approximately 87,000 m^3/day) is piped beneath East River and discharged into one of two settling ponds to promote sedimentation (Fig. 5). After coarse sediment is precipitated, effluent is discharged into an aerated stabilization basin for atmospheric agitated pump aeration for 5-6 d prior to its discharge to a stabilization lagoon (*i.e.,* Boat Harbour). Effluents remain in Boat Harbour for a 20-30 d hydraulic residency before final discharge to the Northumberland Strait through the impoundment upstream of the estuary (Fig. 5).

Effluent discharge over the last 50 years has resulted in the deposition of approximately 577,000 m^3 of unconsolidated contaminated sediments impacted by inorganic and organic contaminants in BH (Hoffman et al., 2017a, 2019; Alimohammadi et al., 2019).

Since 1967, the environmental and human health impacts of the pulp mill and chlor alkali plant effluents on water quality, soil, and sediment contamination have been a major concern (Hoffman et al., 2017a). In 2014, an effluent pipe leak and broken stack precipitator increased the concern and intensity of protests by the PLFN community. This mounting political pressure resulted in the passing of the *Boat Harbour Act* (2015), which mandated that the discharge of mill effluents into the BHTF will cease on January 31, 2020. Following the cessation of effluent discharges, contaminated sediments in BH will be remediated (Hoffman et al., 2017a, 2019; Romo et al., 2019). The goal of the *Act* is to return Boat Harbour to its pre-effluent tidal estuary condition as requested by the PLFN community. However, a detailed characterization of contaminants in sediment and biota in Northumberland Strait are required before remediation begins.

To track the effectiveness of remediation, baseline data is required to predict potential ecological impacts and risks associated with the contaminated sediments in BH and marine environments of the Northumberland Strait. After the *Boat Harbour Act* was passed in 2015, numerous studies have been conducted in and around BH to characterize contaminants in sediments, groundwater, and nearby wetlands. Despite numerous historical studies documenting the impact of effluents on sediments in BH, there is a lack of recent information on the potential impacts on marine sediments and biota of the Northumberland Strait (Romo et al., 2019). The ultimate goal of the *Boat Harbour Act* (2015) is to return BH to its former tidal condition and to hydraulically connect it to the Northumberland Strait. Therefore, it is important to establish current baseline data for marine sediments and biota in Northumberland Strait which can be used for comparison during future monitoring. A key aim of this study was to conduct a baseline assessment of level of contamination in sediments and marine biota of Northumberland Strait.

3.2 Materials and Methods

3.2.1 Review of Secondary Data

In order to determine if contaminants from BH migrated into the marine receiving environment of Northumberland Strait, it is important to gather background information on historical contaminants of BH and the surrounding area for comparison.

Although many historical studies have been conducted in and around BH, there have been few summaries describing spatio-temporal organic and inorganic contaminant characterization. Hoffman et al. (2017a, 2019) conducted a holistic characterization of metal and organic contaminants in BH sediments. These studies reviewed >200 documents (including government reports and peer-reviewed journals) for sediment quality data (JWEL and Beak Consultants, 1992 and 1993; JWEL, 1999, 2001, 2005; Stantec 2013, 2016; Hoffman et al. 2017a, 2019). It was reported in the study that out of all previous sampling events (from 1992-2015), approximately 38% of samples were grabs and the rest (62%) were cores (Hoffman et al. 2017a, 2019) (Fig. 6).

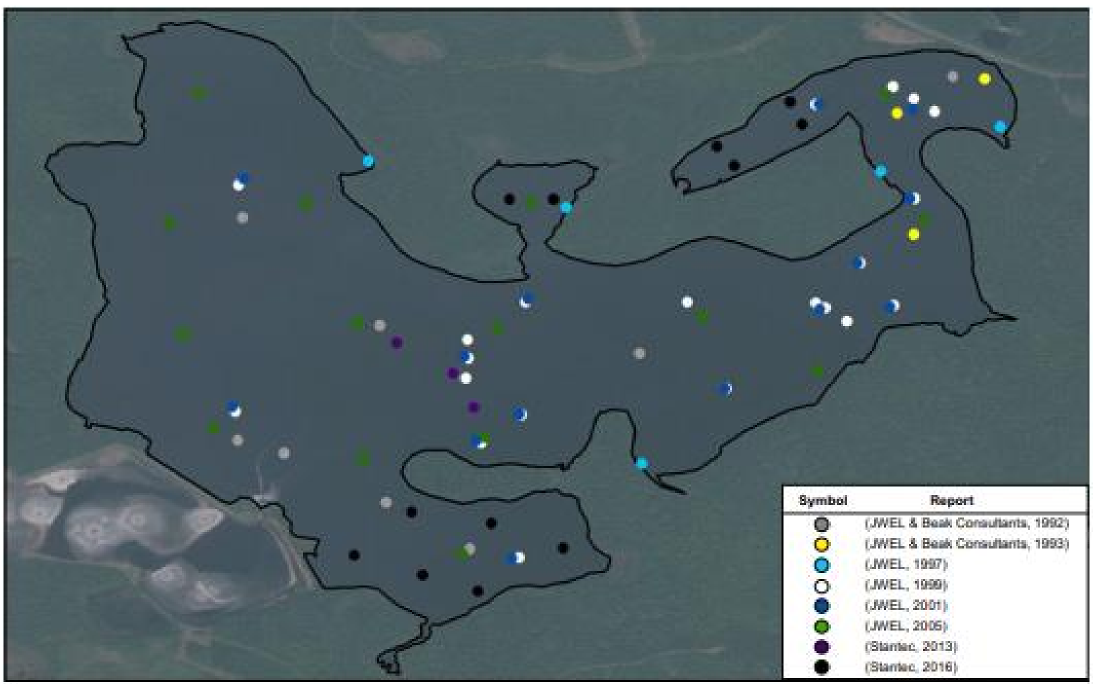

Fig. 6. Spatiotemporal coverage (1992–2015) of sediment sampling sites in Boat Harbour. Colored circles indicate when samples were collected/analyzed (from Hoffman et al., 2017a).

Further, toxic equivalency quotient (TEQ) concentrations for polychlorinated dibenzodioxins and furans (PCDD/F) of 60 samples from 48 stations were also calculated (Hoffman et al., 2017a, 2019). It was reported that six metals: As, Cd, Cr, Pb, Hg, and Zn exceeded freshwater

Probable Effects Levels (PELs) and four: Cd, Cu, Hg, and Zn exceeded marine PELs (Hoffman et al., 2017a).

Sediments across BH were found to be highly organic with mean total organic carbon values ranging from 4 to 27%. Furthermore, all PCDD/F TEQs exceeded the low -effect CCME interim sediment quality guidelines (ISQGs), 66.6% exceeded CCME PELs, and 93.3% exceeded the CCME soil quality guideline for human health. In addition, percent contributions of PCDD/F congeners indicate higher proportions of 2,3,7,8-tetrachlorodibenzofuran (68.6-97.3%) and 2,3,7,8-tetrachlorodibenzo-p-dioxin (10.7-63.8%) in the sediment of Boat Harbour for all TEF categories (Hoffman et al., 2019).

Ferguson's Pond located 2.5 km NE of BH was selected as reference site for this study (Fig. 7) and it was found that BH sediment concentrations of the chemicals of concern were 20 times higher than at this reference site (Hoffman et al., 2017a).

Fig. 7. Location of reference site Fergusons Ponds relative to Boat Harbour (from Hoffman et al., 2017a).

According to Hoffman et al. (2017a, 2019), to return BH to pre-tidal conditions, more local baseline data of sediments and marine biota in the Northumberland Strait marine receiving environment is required. This data is necessary to determine potential ecological impacts to aquatic life (St-Jean et al., 2003; Romo et al., 2019).

To assess quantitative and qualitative data on marine biota from BH, Pictou Harbour, Northumberland Strait, and reference sites, Romo et al. (2019) reviewed government reports and peer-reviewed articles. The review included contaminant concentrations (metals, dioxins and furans, chlorophenols, resins and fatty acids) and sample locations (x, y coordinates in decimal degrees). Romo et al. (2019) reported that many species such as American eels (*Anguilla rostrata*), soft-shell clams *(Mya arenaria*) and quahogs (*Mercenaria mercenaria*), suffered widespread mortality due to early effluent exposure (Seakem Oceanography, 1990). Since 1992, pulp mill effluents in Canada have been regulated under the *Pulp and Paper Effluent Regulations* (PPER) under the *Fisheries Act* (PPER, 1992). Pulp mills are obliged to conduct an Environmental Effects Monitoring (EEM) cycle every 3 years to measure the effects of effluents on fish and fish habitat. After reviewing all available EEM cycles from 1996 until 2016, Romo et al. (2019) reported many inconsistencies in EEM reporting. Although EEM became mandatory in 1992, only four EEM cycles out of seven had reports that were available (JWEL, 1996; Stantec, 2004; Ecometrix Inc., 2007; Ecometrix Inc., 2016). The second, fifth and sixth EEM cycles were unavailable, but results from the second cycle were summarized in subsequent reports using data derived from Andrews and Parker (1999) and the fifth and sixth cycle results were inferred from the seventh EEM cycle report (Ecometrix Inc., 2016).

In the available reports, there were inconsistencies between different EEM cycles. For instance, to assess impacts on fish and shellfish, the first EEM cycle selected winter flounders and rock crabs for analyzing resin and fatty acids and morphological characteristics with reference samples collected from Merigomish Harbour. Blue mussels were analyzed for 10 dioxins and furans congeners, with reference sites selected from Caribou Island (JWEL, 1996). In contrast, the third EEM cycle analyzed blue mussel (*Mytilus edulis)* and mummichog (*Fundulus heteroclitus)* for immunological and morphological endpoints with reference sites from Merigomish Harbour and Logan's Point (Fig. 8).

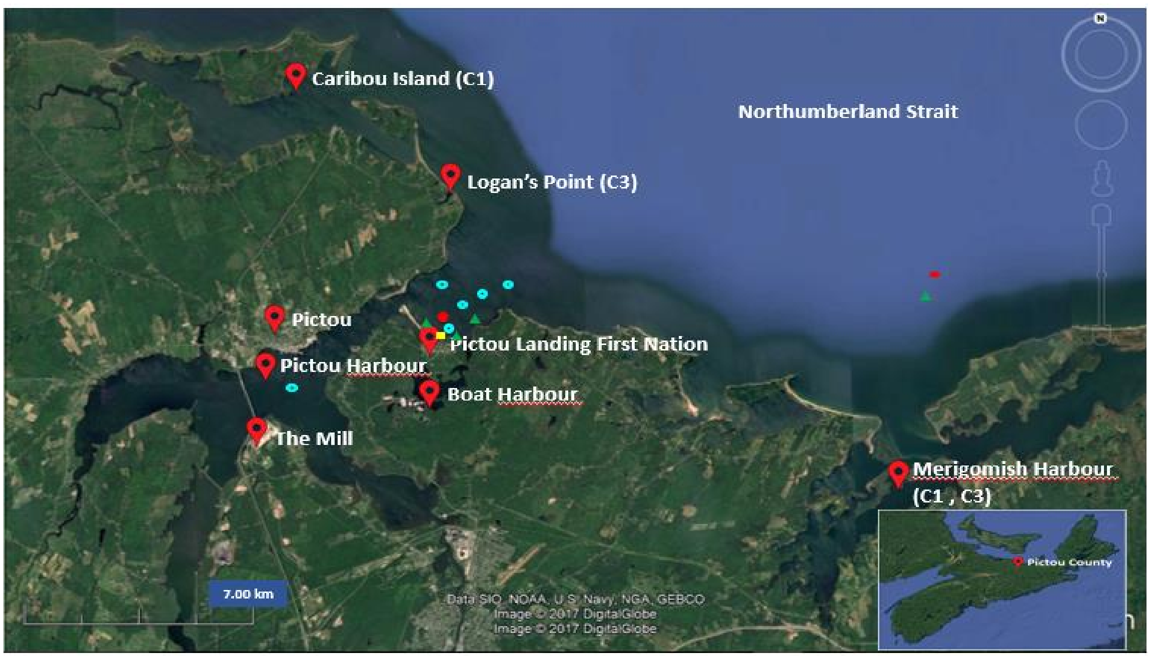

Fig. 8. Location of Boat Harbour in Pictou County, Nova Scotia. Blue circles represent Blue mussel (*Mytilus edulis*) sampling stations, green triangles represent Rock crabs (*Cancer irroratus*) sampling stations, red circles represent American lobsters (*Homarus americanus*) sampling stations and yellow squares represent soft shell clams (*Mya arenaria*) sampling locations. C1, C2 and C3 represent reference locations used in EEM cycles 1, 2 and 3 cycles, respectively (from Romo et al., 2019).

All EEM cycles reported limited impacts on marine biota, despite there being a lack of contaminant guidelines for biota tissue and limited local reference data (Romo et al., 2019) (Fig.

8). In addition, despite a chlor-alkali facility which operated for 21 years and discharged effluent into Boat Harbour, mercury (Hg) has never been analyzed, nor has methyl mercury (Me-Hg). Chlor-alkali facilities are potentially a major source of mercury as they generate sodium hydroxide, chlorine, and hydrogen by using mercury as a catalyst (Walker, 2016; Dillon Consulting Limited, 2019).

Furthermore, two dioxin and furan congeners 2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) and 2,3,7,8 tetrachlorodibenzofuran (2,3,7,8-TCDF) were not analyzed in the first EEM cycle contradicting the claims made in the reports (JWEL, 1996; Romo et al., 2019). Overall, there was a lack of consistency in analyses, species used in different cycles, and limited reference sites, which make it difficult to use this data for future reference.

Although numerous studies have reviewed sediment quality and characterized contaminants in BH (Hoffman et al., 2017a, 2019; Romo et al., 2019) current assessment of contaminants in marine sediments and biota in Northumberland Strait is required. This baseline data can be used to compare against potential future monitoring programs in the area. Studies in and around BH (Hoffman et al., 2017a, 2019; Romo et al., 2019) have recommended to prepare a baseline dataset for sediments and marine biota for the marine receiving environment of Northumberland Strait.

The aim of this study as stated in chapter 1 is to:

1) Assess levels of contamination of metals, total mercury, methyl mercury, dioxins and furans in sediments and biota of the marine environment of Northumberland Strait; and

2) Prepare the baseline pre-remediation data which can be used during and after remediation for monitoring purposes.

3.3 Sampling

Research objectives were achieved by using multiple lines of evidence to measure contaminant concentrations in marine sediments and in marine biota at different trophic levels. The first line of evidence was bulk sediment sampling (0-15 cm). The second line of evidence was marine biota sampling using multiple species including: American lobster (*Homarus americanus*), Rock crab (*Cancer irroratus*), and Blue mussel (*Mytilus edulis*). The third line of evidence was passive sampling by diffusive gradient thin films (DGTs).

3.3.1 Sampling Stations

Sixteen sampling stations were selected to achieve the 7-8 km spatial coverage from the mouth of the estuary (where effluents get discharged after final treatment) to offshore areas in the marine environment of Northumberland Strait. Another eight stations were selected for blue mussels along the coastline of Pictou Harbour in Northumberland Strait. Stations in Northumberland Strait were then divided along two transects (North East (NE) and North (N)) from the estuary mouth into Northumberland Strait. NE and N Transects extended approximately 7 and 8 km, respectively into the Northumberland Strait (Fig. 9) (Table 2). Following is the cumulative distance of sampling station from BH.

Table 2. Distance of sampling stations from BH

Stations	Cumulative distance from BH
N1-N3	0.80-2.00 km
N4-N6	3.80-5.00 km
N7-N8	6.00-7.00 km
NE1-NE6	1.00-3.00 km
NE7-NE8	6.50-8.00 km
M1-M2	2.50-3.00 km
M3-M4	0.50-1.00 km
M5-M6	1.50-3.00 km
M7-M8	6.50-7.50 km

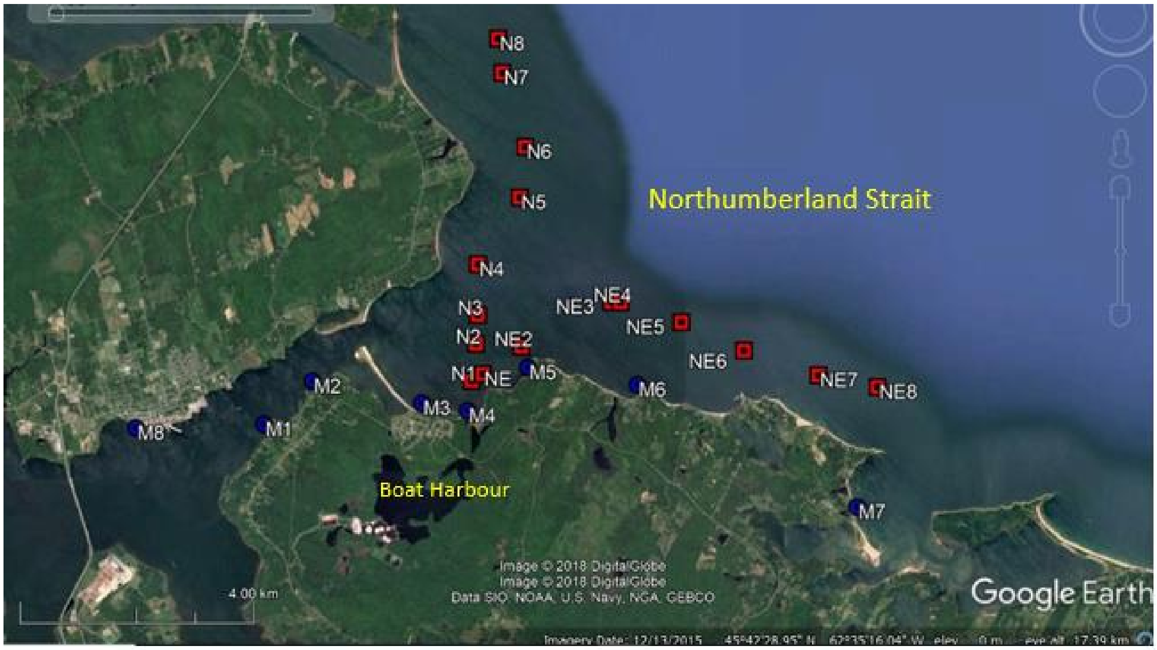

Fig. 9. Sediment and marine biota sampling stations. Red squares represent sediment sampling stations, American lobster (*Homarus americanus)*, and Rock crab (*Cancer irroratus)* sampling stations. Blue circles represent blue mussel (*Mytilus edulis)* sampling stations.

Sampling stations were divided into three areas: near-field area (1-3), mid-field area (4-6), and far-field area (7-8) along each transect to get a wide representation of samples (Table 2). Sampling stations were selected to obtain two duplicate samples in the near-field area (i.e., N1-N3 and NE1-NE3), considered contaminated *a priori*. Blue mussel stations were selected to get a spatial coverage over approximately 8 km along the shoreline of Pictou Harbour. Stations M3, M4, and M5 were considered near- field, M1, M2, and M6 as mid -field and stations M7 and M8 as far- field. Sediment sampling was completed during two field seasons. The first in May 2018 and second in July 2019. Sampling positions were recorded using hand-held and boat Garmin Global Positioning System (GPS) units (Appendix A Image 1).

Ten sampling stations were selected near the estuary mouth for the deployment of DGTs and ten stations were selected in BH. Ten chelex binding gel DGTs disc for metals (As, Cd, Cr, Cu, Pb, and Zn) and ten 3-mercaptopropyl-functionalized silica (MFS) binding gel for total mercury (THg) were deployed at each site.

3.3.2 Sediment Sampling and Analysis

Twelve sediment samples were collected during two field sampling seasons in 2018 and 2019. Six samples were collected in July 2018, including five samples from NE transect (NE4- NE8) and one sample from N transect (N4). Long gravity corer (approximately 1.25 m) 2416 B45 (Wildco®) was used to collect samples in 2018 (Appendix A Image 2). Surface sediment samples from 0-15 cm depth were collected as this horizon is the most biologically active (Walker and Grant, 2015; US EPA, 2019). Rocky substrate in Northumberland Strait prevented sediment samples using the gravity corer at stations N5-N8 in 2018. Six samples in 2018 were collected on a lobster fishing boat (*JB & Stephanie*) (Appendix A Image. 3).

In May 2019, the second round of sediment sampling was completed from the near- field stations. Sediment samples were collected from six stations in the N transect (*i.e.,* N1-N6). All the samples were collected by using 316 Stainless Steel, 152 x 152 mm ponar grab (Wildco®) from the 0-15 cm horizon. To avoid disturbance of surface sediment care was taken to allow surface seawater in the grab to drain away (Walker and Grant, 2009; Walker et al., 2013). Near-field samples were collected from shallow water on small aluminium motorboat (Appendix A Image. 4). Sediment sub-samples were then transferred to individual clean glass jars; 250 mL jars were used for metals, and dioxins and furans, and 120 mL jars were used for total organic carbon (TOC).

All sediment samples were analyzed by AGAT laboratories, accredited by the Standards Council of Canada. Samples were analyzed for grain size, TOC, 25 metals (Al, Sb, As, Ba, Be, B, Cd, Cr, Co, Cu, Fe, Pb, Li, THg, Mn, Mo, Ni, Se, Ag, Sr, Tl, Sn, U, V, Zn), total mercury (THg), and dioxin and furans. Although 25 metals were analyzed, this study focussed on the priority metals (i.e., As, Cd, Cr, Cu Pb, Zn, Hg). These metals exceeded CCME PEL thresholds in BH sediments (Hoffman et al., 2017a). Samples for grain size were analyzed by sieve and a pipette based on the ASTM D-422-63 (ASTM, 2007). TOC was determined by using titration based on MA 405-C 1.1. Metals were analyzed by using multi-element inductively coupled plasma-mass spectrometry (ICP-MS) based on US-EPA SW 846 6020A/3050B and SM 3125 (Center of Expertise in Environmental Analysis of Quebec, 2014; USEPA, 1998a). Analysis of dioxins and furans was conducted using high-resolution mass spectrometry (HRMS) in accordance with EPA 1613 (USEPA, 1994). All sediment concentrations were expressed in dry weight (dw).

3.3.3 Marine Biota Sampling and Analysis

Thirteen adult American lobster (*Homarus americanus*) with carapace length (CL) between 80-125 mm and thirteen composite Rock crab (*Cancer irroratus*) samples (comprising 6-8 individuals per station) between 102-113 mm CL were collected from stations along the N and NE transects (Fig. 9). Lobsters and rock crabs were collected from the same stations as sediment samples (Appendix A Image 5 and 6). All samples were collected from a lobster fishing boat (*JB & Stephanie*) in July 2018.

Traps with Department of Fisheries and Ocean (DFO) scientific tags for lobsters and rock crabs were deployed on July 9, 2018 and retrieved on July 11, 2018 (Appendix A Image 7) (Fig. 9). Eight blue mussels (*Mytilus edulis)* composite samples of 50-65 mm shell length (comprising 6-30 individuals per station) were collected along the shoreline of Pictou Harbour from eight stations (Fig. 9). Blue mussels were collected on July 10, 2018 by hand from inter-tidal stations during low tide (Appendix A Image 8). DFO scientific licenses were obtained prior to sampling (License No.: SG-RHQ-18-071) (Appendix A Image 9). The number of species collected during sampling was in accordance with licenses issued. After collection, all the samples were transferred into a -20^{o}C freezer overnight and delivered to AGAT laboratories on July 12, 2018. American lobster, rock crab, and blue mussel whole body tissues were analyzed for metals (As, Cu, Cd, Pb, Zn, THg), and dioxins and furans by AGAT laboratories. Two samples from near-field stations and one sample from far-field stations of each species were also analyzed for MeHg. Metals were analyzed based on US-EPA 350 with ICP/MS and mercury was analyzed with CV/AA based on US-EPA 248.6 (USEPA, 2019). HRMS was used for dioxins and furans analysis based on US-EPA 1613 in whole tissue (USEPA, 1994). MeHg was analyzed based on M-10220 with digestion, aqueous ethylation, purge, trap, and CVAFS with an automated system (USEPA, 1998). All tissue concentrations were expressed as wet weight.

3.3.4 Passive Sampling Using DGTs disc and Analysis

Passing sampling is the use of an abiotic device to monitor contaminants in an environmental medium, which obtains a measurement without active media transport (Alvarez, 2010). Passive samplers based on DGTs technique was used in this study.

DGT® was originally developed by Davison and Zhang from Lancaster University in order to measure free ion concentrations (bioavailability) in bulk seawater and sediment porewater (Davison and Zhang, 1994, 2012). DGTs measure porewater concentrations using Fick’s first law of diffusion and relies on an ion-exchange resin layer, which is separated from the bulk solution by an ion-permeable hydrogel (Zhang et al., 1998). A typical DGT disc consists of a binding gel layer, an ion-permeable diffusive gel layer, a filter member and plastic cap and base (Fig. 10).

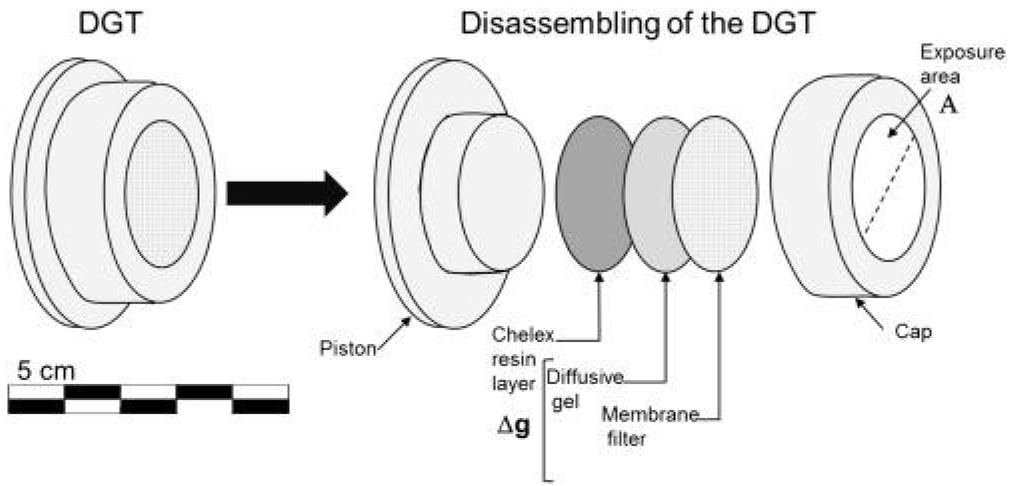

Fig. 10. Schematic representation of a DGT unit assembled and disassembled, A is the exposure surface area of the membrane, Δg is the thickness of the diffusion layer (diffusive gel +filter membrane) (from Desaulty et al., 2017).

When DGT discs are deployed in an environmental media, a diffusive gradient is created across the bulk solution and the resin gel. The resin gel acts as a sink, inducing the flux of ions from sediments through the diffusive layer (Zhang and Davison, 1995; Ruello et al., 2008). Metal ions then pass through a gel diffusion layer and bind to the chelating or ion exchange resin. Two results which can be obtained from DGT analyses are mass accumulated by DGT resin and time weighted estimated water concentration (Zhang and Davison, 1995).

Contaminants taken up by organisms accumulate in tissues, organs, or throughout the whole body. Bioaccumulation of contaminants occurs when the rate of uptake exceeds that of excretion. In theory, such a time integrated characteristic is also represented by the DGTs technique, where the resin gel in DGTs behaves like a tissue (Guan, 2019). Therefore, DGTs can be used to mimic contaminants uptake and bioaccumulation processes similar to fish (Alvarez, 2010; Guan, 2019). The resin (adsorptive) gels used in DGTs are selective towards certain metal species; for instance, chelex resin is used for As, Cd, Cr, Cu, Pb, and Zn and MFS are used for THg. Therefore, it can be used to measure a variety of analytes with suitable adsorbents.

To assess the level of metals and THg in sediment pore water of BH and the downstream estuary, forty DGT discs (twenty in BH and twenty in estuary) were deployed.

Forty piston sediment probe DGTs were purchased from DGT® Research, Lancaster UK. The discs had plastic base (2.5 cm diameter) with 0.4 mm resin gel layer, 0.8 mm diffusive gel layer, and 0.135 mm filter (Appendix A Image 10). Out of forty discs, twenty were with chelex binding gel (used for metal As, Cd, Cr, Cu, Pb, and Zn) and twenty with MFS binding gel were used for THg analysis. Chelex and MFS disc were deployed at the same station (*i.e.* two discs at each station). DGTs disc with chelex gel (metals) were labelled as ESM1-10(for estuary) and BHM1-10(for BH) and MFS gel disc (THg) were labelled as ESHG1-10, (for estuary) and BHHG1-10 (for BH). DGTs disc were tied to cinder blocks with plastic cable to avoid any cross contamination (Appendix A Image 11).

The equilibrium time required by the DGTs disc is different for freshwater and marine environments. Therefore, DGTs disc were deployed for one week in the marine environment of the estuary (May 21-28, 2019). As the equilibrium time for DGT discs in freshwater is one month, (personal communication, Lord, Heather, April 30, 2019) DGTs in BH were deployed May 21-June 18, 2019.

All the discs were shipped to Bureau Veritas (accredited by the Standards Council of Canada). Metals were analyzed by ICPMS digestion by using EPA 6020b R2 m (USEPA, 2014) and THg was analyzed by CV based on BCMOE BCLM Oct2013 m (Austin, 2015).

3.4 Quality Control

Nitrile gloves were used during each sample collection to minimize potential cross-contamination. Samples were collected in laboratory supplied glass jars in order to minimize contamination (Appendix Image 12). Samples were uniquely labelled, and control was maintained using chain of custody forms. All samples were stored in freezers at -20°C and transported to laboratory in coolers using ice packs. Blind field duplicate for lobsters were collected for every 10 samples. In this study 13 lobsters were collected which includes two field duplicates. Method blanks, spike blanks, and matrix spikes were analyzed for of each batch samples by AGAT laboratory. Spike blanks results were control charted and met specific acceptance criteria (Appendix B).

3.5 Data Analysis

SPSS statistical package (version 25), Microsoft Excel™, Minitab®, and Sigma Plot™ were used for data analysis. One sample t-test was performed by using SPSS™ on each metal (with the exception of Cd, Hg) to determine whether sample means were statistically different from background means. Mean sediment metal background concentrations from Nova Scotia harbours and inlets studied by Loring et al. (1996) were used in this study (Table 6). Background values represent concentrations of metals from relatively pristine environments without anthropogenic impacts (Loring et al., 1996). A Pearson correlation was performed using SPSS™ to assess the correlation between metals, grain size and TOC. In this study, the geoaccumulation index (Igeo) was also calculated to assess the metal pollution in sediments compared to background levels (Admano et al., 2005). The geoaccumulation index was introduced by Muller (1969) and is sometimes used in ecological risk assessment by using equation (Eq. 1):

$$Igeo = \log_2 . C_n / 1.5 B_n$$

Where Cn is sediment metal concentration and Bn is background sediment metal concentration. Factor 1.5 is introduced to minimise the effect of possible variations in the background values which may be attributed to lithologic variations in the sediments (Muller 1969; Stoffers et al., 1986). The descriptive classes for increasing Igeo values developed by Muller (1969) are described in (Table 5). Box plots and graphs for metals were developed using Sigma Plot™.

For metals, Canadian Council of Ministers of Environment (CCME) marine sediment quality guidelines (SQGs) were used to compare against sediment contaminant burdens. Two SQGs exist for marine sediments; 1) Probable Effect Level (PEL) and 2) Interim Sediment Quality Guidelines (ISQGs) (Canadian Council of Ministers of the Environment, 2019a). Sediment concentrations above PEL are often considered heavily contaminated and likely to impair aquatic biota, concentrations between PELs and ISQGs are considered moderately contaminated, and concentrations below ISQGs are considered uncontaminated (Canadian Council of Ministers of the Environment, 2019a). For dioxins and furans, toxic equivalency (TEQ) concentrations of samples were calculated by multiplying individual PCDD/F congener concentrations with associated toxic equivalency factors (TEFs) for each congener (Canadian Council of Ministers of the Environment, 2019). TEQ concentrations were determined using the World Health Organization (WHO) established TEFs for fish, birds, and humans (World Health Organization, 2006).

For metals in tissue samples, Canadian Food Inspection Agency (CFIA) guidelines for chemical contaminants and toxins in fish and fish products were used (Canadian Food Inspection Agency, 2019). Only As, Pb, and Hg tissue data were able to be compared against the CFIA guidelines as there are no guidelines available for other metals. For methyl mercury in biota tissue, Canadian tissue residue guidelines for the protection of wildlife consumers of aquatic biota (2019) was used for comparison (Canadian Council of Ministers of the Environment, 2019b). If metal and dioxins and furans concentrations were below detection limits (DL), then a 1/2DL concentration was used in calculations (MacAskill et al., 2016; Zhang et al., 2019).

3.6 Result and Discussion

3.6.1 Sediment Contaminant Concentrations

Sediments collected were light brown in color. Grain size of most sediments were coarse, ranging from 60-100 % (>75µm). Out of 12 samples, two mid field samples (N4, NE4) and 1 far-field (NE8) were found to be fine grain sizes with values 42%, 34%, and 46% above the sieve size of >75µm respectively. TOC content was low in all the sediment samples with a range of <0.3-1.5%.

Sediment metal concentrations (As, Cd, Cr, Cu, Hg, Pb, Zn) were detected below marine sediment interim sediment quality guidelines (ISQGs) (Fig. 11). Results from the one-sample t-test showed a significant difference ($p \leq 0.001$) between means of each metal (As, Cr, Cu, Pb, Zn) relative to mean background metal concentrations. Arsenic was detected below the ISQGs ranging between 3-7 mg/kg (DL=1 mg/kg). Sediment Cr, Cu, Pb, and Zn concentrations were also below ISQGs ranging from 13-19 mg/kg (DL=2 mg/kg), 1-11 mg/kg (DL=2 mg/kg), 1.9-12.4 mg/kg (DL=0.5 mg/kg), and 18-59 mg/kg (DL=5 mg/kg), respectively (Table 3). Sediment Cd and Hg concentrations were below DLs (0.3 mg/kg and 0.05 mg/kg, respectively) across all sampling stations, so are not presented. Dioxins and furans in all samples were detected below CCME ISQGs.

Table 3. Descriptive statistics of sediment metal concentrations from sampling stations mg/kg(dw) (n=12).

Metals	Minimum	Maximum	Mean	Standard Deviation
As	3.00	7.00	5.08	1.16
Cr	3.00	19.00	10.83	6.32
Cu	1.00	11.00	5.33	3.62
Pb	1.90	12.40	6.58	4.09
Zn	18.0	59.00	38.50	15.41

*dw- dry weight

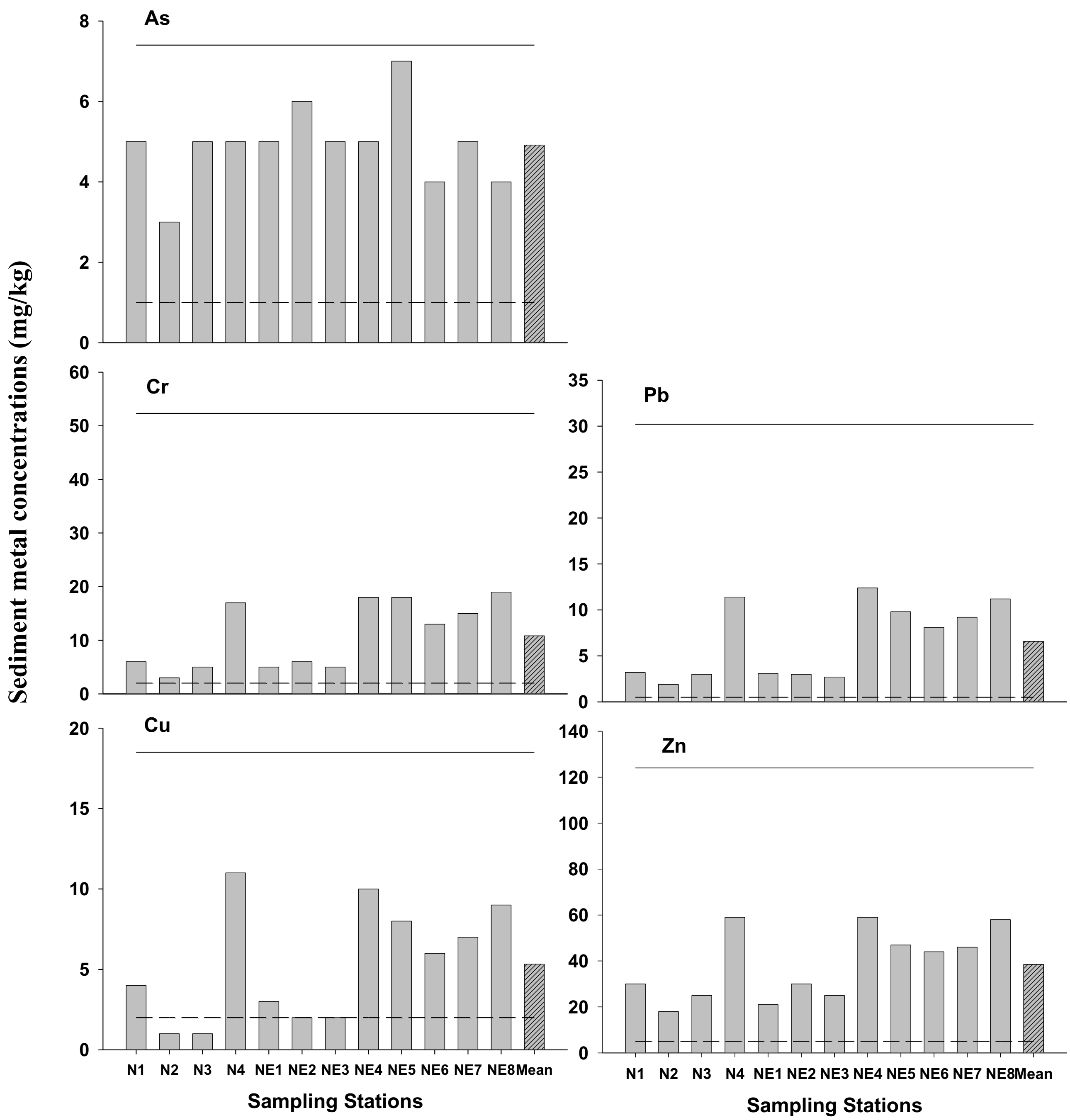

Fig. 11. Sediment metal concentrations across all sampling stations (*n*=12). Solid horizontal line represents ISQG and dotted horizontal line indicates detection limit. Concentration in sediments expressed in dry weight.

Pearson correlation analysis indicated that there is a strong positive significant relation of As (*r*=0.61 and *p*=0.03) ,Cr (*r*=0.71, *p*=0.01), Cu (*r*=0.64 *p*=0.02), Pb (*r*=0.65 *p*=0.02), and Zn (*r*=0.71, *p*=0.03) with TOC (Table 4).

Table 4. Pearson's correlation matrix for sediment metal concentration, TOC and grain size from sampling stations in Northumberland Strait.

Parameters	As	Cr	Cu	Pb	Zn	TOC	Grain size
As	1.00						
Cr	0.36	1.00					
Cu	0.34	0.95**	1.00				
Pb	0.34	0.99**	0.97**	1.00			
Zn	0.33	0.97**	0.97**	0.98**	1.00		
TOC	0.61*	0.71**	0.64*	0.65*	0.62*	1.00	
Grain size	-0.37	-0.98	-0.97	-0.99	-0.97	-0.70	1.00

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Note: *r* value $\leq$ 0.30 is considered weak, r > 0.30 and r <0.70 is considered moderate and r $\geq$ 0.70 is considered a strong relationship.

The positive correlation of metals with TOC indicated that organic content plays an important role in metal ion adsorption in sediments. In previous studies, it has been documented that organic matter in water sorbs metals (Rule, 1986; Lin and Chen, 1998; Bartoli et al., 2012. A strong negative significant relation was observed between Cr (*r*=-0.98, *p*<0.01), Cu (*r*=0.97, *p*<0.01), Pb (*r*=-0.97, *p*<0.01), and Zn (*r*=-0.70, *p*<0.01) with grain size (Table 4). It has been documented that fine grain particles tend to have relatively higher metal content due to high specific surface areas of particles (Rubino et al., 2000; Bartoli et al., 2012). Most of the grain sizes were coarse across sampling stations, leading to less adsorption of contaminants. Three sampling stations (N4, NE4, N8) which exhibited finer grain size showed a higher concentration of metals compared to other stations (Fig. 11).

Igeo for each metal was calculated using (Eq. 1) for quantitative measurement of pollution at each site. Results indicated that the sites are unpolluted with values below 0 (*i.e.* As (-2.64), Cr (-3.18), Cu (-3.64), (-3.32) and Zn (-3.24). Classification of degree of pollution was done according to Igeo values indicated in Table 5.

Table 5. Classification of geo-accumulation and pollution level (adapted from Abrahim and Parker, 2008).

Igeo	Classification	Pollution status
<0	0	Unpolluted
0-1	1	Unpolluted to moderately polluted
1-2	2	Moderately polluted
2-3	3	Moderately to heavily polluted
3-4	4	Heavily polluted
4-5	5	Heavily to severely polluted
>5	6	Severely polluted

After the *Boat Harbour Act* (2015) was passed, Nova Scotia Lands retained GHD to conduct a baseline assessment to characterize contaminants in and around Boat Harbour. In 2017, GHD collected sediment samples for metals and dioxin/furan contamination assessment of the estuary mouth and Northumberland Strait. Four sediment samples were collected from the 0-15 cm depth horizon (Fig. 12) (GHD, 2018). Sediment metal concentrations from GHD were compared to those of the present study using a one-way ANOVA. A Ryan-Joiner normality test and Bartlett's Test for homogeneity of group variances were run in *Minitab® 18.1* (Minitab Inc., 2017) to validate parametric test assumptions. Heterogeneous or non-normal data ($\alpha \leq 0.05$)

were log-transformed and retested using the above tests, and if still failing to meet parametric assumptions, were analyzed non-parametrically by Mann-Whitney analyses with differences considered significant if $p \leq 0.05$.

The sediment metal concentrations of the present study did not significantly differ from those previously sampled by GHD for As ($p=0.17$), Cr ($p=0.19$), Cu ($p=0.7$), Pb ($p=0.8$), and Zn ($p=0.17$). Sediment concentrations in the present study s ranged as follows: As: 1-7.8 mg/kg, Cr: 2.5-23 mg/kg, Cu: 1-43 mg/kg, Pb: 1.9-28 mg/kg, and Zn: 10-46 mg/kg (Fig. 13). Results from GHD sampling showed the same pattern as the present study with all sediment metal concentrations below the ISQGs. GHD data demonstrated decreasing sediment concentrations as distance from the estuary increased. Northumberland Strait sediment metal concentrations showed a sharp decrease, suggesting dilution of or attenuation of contaminants migrating from Boat Harbour.

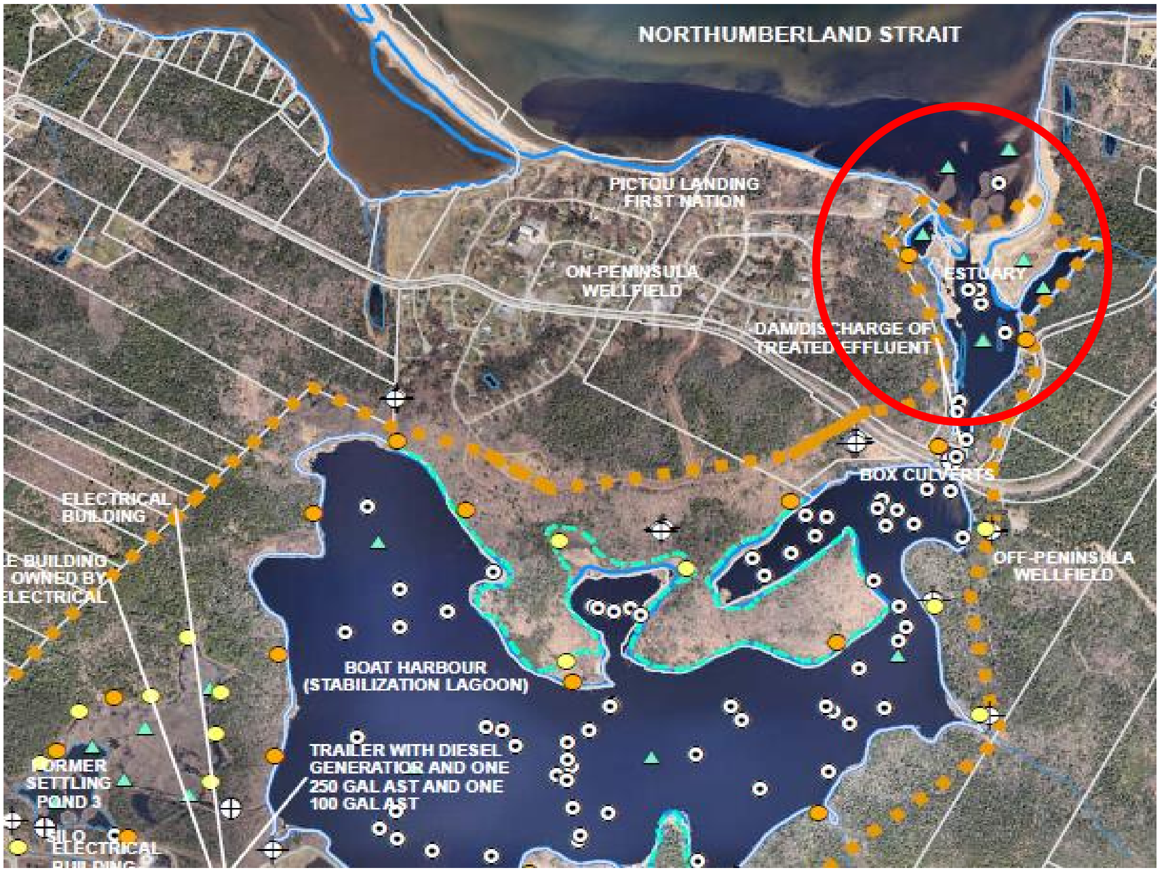

Fig. 12. GHD sediment sampling stations from the estuary (red circle). Blue triangles represent sediment sampling stations (adapted from GHD, 2018).

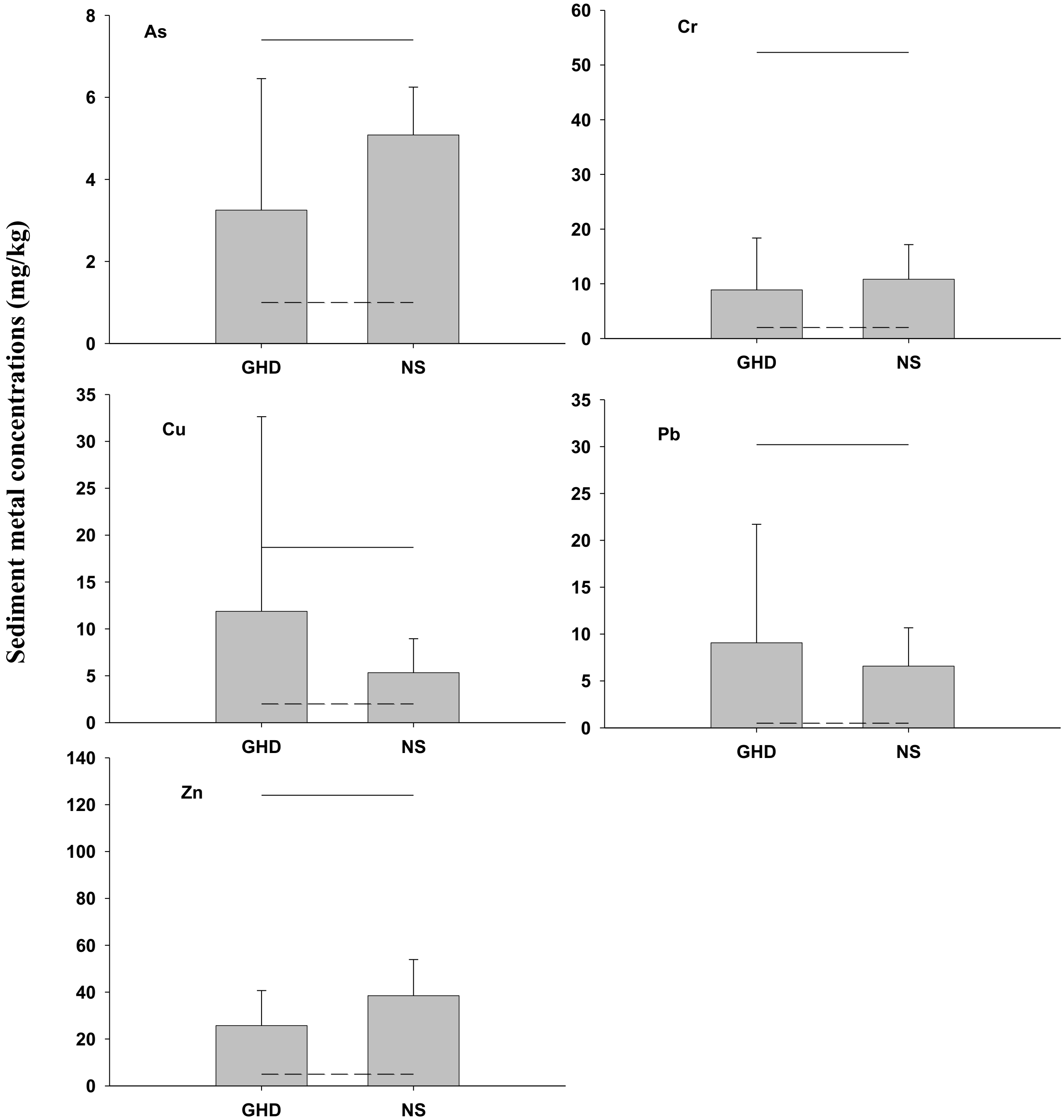

Fig.13. Mean metal concentration in sediments from Northumberland Strait in July 2018 and May 2019 (NS18/19) (*n*=12) and sediments collected by GHD in 2018 (*n*=4). Horizontal straight line represents ISQGs (CCME, 2019) and dotted horizontal line represents DL.

Sediments of many coastal regions adjacent to industrial areas in Nova Scotia are large sinks for metallic contaminants (Loring et al., 1996; Zhang et al., 2019a, b). To understand the broader picture of metal contamination in the marine environment, the concentration of metals in this study is compared with different studies from harbours and inlets across Nova Scotia. These studies include contamination from industrial effluents, municipal and residential sewage, agricultural discharge, marine transportation, fish and fishing process, and coastal residences (Stewart et al., 2019).

In general, the concentration of metals (As, Cd, Cr, Cu, Hg, Pb, and Zn) in this present study were relatively low compared to other Nova Scotian studies. As the metal concentrations were generally lower than in other studies across Nova Scotia and the Maritimes, marine sediment metal concentrations do not exhibit a pollution signature from effluents derived from BH (Table 6). However, results from this present study can be used as a baseline for future monitoring studies conducted during and post-remediation.

Northumberland Strait sediment metal concentrations were low, suggesting that the objective of using BH as sedimentation lagoon worked effectively to contain contaminants in pulp mill effluent. Most contaminants reported by Hoffman et al. (2017a, 2019) appear to have been retained in Boat Harbour sediments. There was no signature of migration of contaminants from the BHTF to the Northumberland Strait receiving environment. The other possible reason that this study found no impact on marine sediment could be a distance of sampling sites from BH. The sampling stations that were selected were approximately 0.5-8 km away from the Boat Harbour treatment facility. As the Northumberland Strait is a high energy dispersive receiving environment, contaminants released from BH may have undergone dilution and attenuation.

***Table 6.** Comparison of metals concentrations (mg/kg) in sediment, mussel and lobster tissue by study (adapted from Walker and Grant, 2015).

Location	As	Cd	Cu	Hg	Pb	Zn	Reference
Sediment							
Northumberland Strait, NS, Canada (DL) (dw)	3.0-7.0 (1.0)	<0.3 (0.3)	2.0-11.0 (2.0)	<0.05 (0.05)	1.9-12.4 (0.5)	18-59 (5.0)	Present study
Isaacs and Country Harbours, NS, Canada (dw)	5.0-40.0	<0.3-0.9	3.0-25.0	<0.05-0.16	2.3-26.0	18-80	Walker and Grant (2015)
Isaacs Harbour, NS, Canada (dw)	2.2-278	0.06-1.53	4.3-179	<0.05-16.0	2.2-126	19.3-142	Walker and Grant (2015)
Wine Harbour, NS, Canada	4-568	0.09-0.91	6.8-30.3	<0.05-74.3	5.4-53.4	26.1-77.6	Little et al. (2015) *
Seal Harbour, NS, Canada	1.2-445	0.02-0.96	1.5-25.2	<0.05-1.30	1.6-33.9	16-90.3	Walker and Grant (2015) *
Sydney Harbour, NS, Canada (dw)	4.0-33.0	0.3-1.10	2.2-71.0	0.10-0.49	4-120	31-210	Walker et al. (2013a, b)
Outer Lunenberg Harbour, NS, Canada	10-20	ND	12-34	ND	52-10	17-24	Envirosphere Consultants (1996) *
Halifax Harbour, Shipyard, NS, Canada	17-34	ND-1.3	64-533	ND	67-555	179-1429	Carter et al. (2004) *
Bay of Fundy, NS, Canada	ND	0.02-0.04	9.3-17.0	ND	ND	35.1-65.5	Chou et al. (2003) *
Background in coastal sediments, NS, Canada (dw)	20	0.4	40	0.10	40	150	Loring et al. (1996)
CCME ISQG	7.24	0.7	18.7	0.13	30.2	124	CCME (2019)
CCME PEL	41.6	4.2	108	0.70	112	271	CCME (2019)

Note-DL- detection limit for present study presented in parentheses; nv- no guideline value; * data reported did not specify whether wet weight or dry weight; ND- not determined; dw-dry weight; CCME, ISQG, and PEL- Canadian Council of Ministers of the Environment, Interim Sediment Quality guideline, and Probable Effects Levels (CCME, 2019a).

3.6.2 Biota Tissue Contaminant Concentrations

American lobster (*Homarus americanus)* (*n*=13)*,* rock crab (*Cancer irroratus)* (*n*=13), and blue mussel (*n*=8) whole-body tissues were analyzed for metals (As, Cu, Cr, Cd, THg, Pb and Zn), dioxins and furans, and methyl mercury (MeHg). Only As and Pb concentrations were compared to CFIA guidelines, as CFIA guidelines do not exist for other metals (Cu, Cr, Cd, and Zn) (CFIA, 2019). Arsenic concentrations in lobster and crabs exceeded CFIA guidelines (3.5 mg/kg) in all stations ranging from 4-10 mg/kg (lobster) and 2-5 mg/kg (rock crabs) (Fig. 14). Pb concentrations in all stations were below DLs (0.4 mg/kg) in lobster, and also rock crab except at station N3, where concentrations were above the CFIA limit of 0.5 mg/kg. Although Cr has no CFIA guidelines it was also below DLs (2 mg/kg) across all sampling stations in lobster and crab tissue (Fig. 14). Zn was detected above the DL (5 mg/kg) ranging between 18-37 mg/kg and 24-42 mg/kg in lobsters and crabs, respectively.

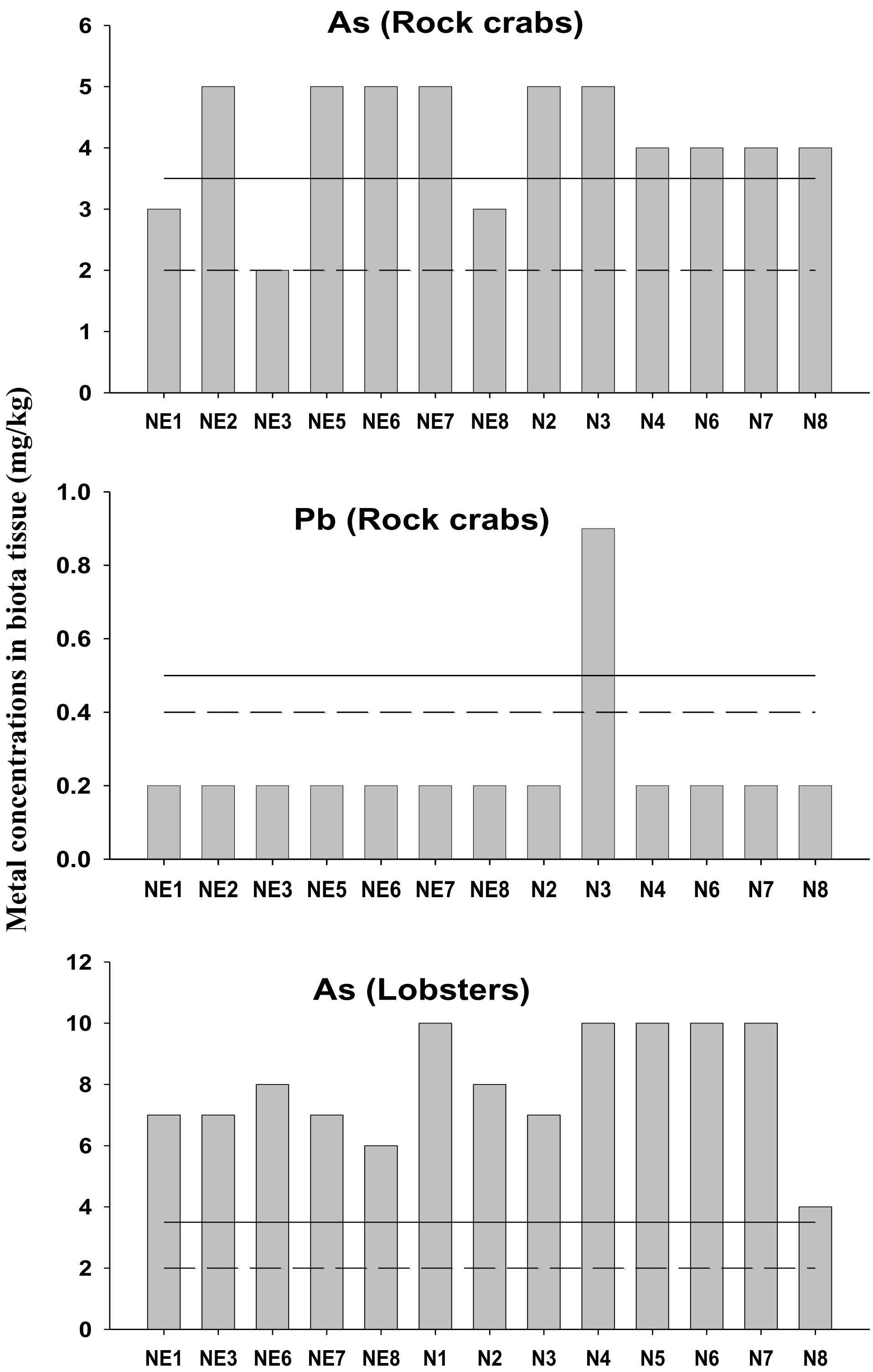

Fig. 14. Metal concentrations in rock crab (*Cancer irroratus*) (*n*=13) and lobster (*n*=13) (*Homarus americanus)* tissue. Horizontal straight line indicates CFIA guideline and dotted horizontal line indicates DL. Concentration of tissue expressed in wet weight

All metal concentrations were below DLs in blue mussel (*Mytilus edulis*), except Zn with measured tissue concentrations between 7-19 mg/kg (DL=5 mg/kg). Mercury which has a CFIA guideline of 0.5 mg/kg was not quantified above the DL of 0.05 mg/kg in all three biota species. For dioxins and furans, there are CFIA guidelines for 2,3,7,8 TCDD (dioxin), which represents the TEQ of the PCDD/F mixture, and which is 0.02 ng/kg (under review, CFIA, 2019). All tissue samples were below DLs in all three marine biota species for dioxins and furans. All three species were also analyzed for MeHg.

There is a paucity of background metal concentration data in the Maritime region for marine biota. To determine if arsenic concentrations detected in lobster tissue samples in the present study were representative, results were compared to those of a similar study conducted by Maltby et al. (2018 unpublished data) in the Northumberland Strait. Maltby et al. (2018) collected samples of adults, sub-adults, and juvenile American lobster from three different sites in Northumberland Strait, Ballantynes Cove (~45 km from Boat Harbour outfall), Merigomish (~15 km from Boat Harbour outfall), and Pictou Road (>1 km from Boat Harbour outfall). Results from Maltby et al. (2018) showed a similar pattern of metal concentrations to the present study, reporting some exceedances in As concentrations in adult lobsters from all stations. Arsenic concentrations across all stations ranged from below DL to 23 mg/kg, results comparable to this study. Lead was also undetected in all stations assessed by Maltby et al. (2018). The results for the metals lacking CFIA guidelines (Cd, Cr, Cu, Zn) were also comparable (Table 7).

To determine if elevated As concentrations in marine biota were only limited to Northumberland Strait or was a broader regional issue, results were also compared with other regional studies in Nova Scotia and the Maritimes. American lobster and rock crab samples collected by Walker and Grant (2015) from Issacs and Country harbour (adjacent historical gold mining tailings site) and Sydney Harbour (contaminated by coking and steel manufacturing) in Nova Scotia also reported As exceedances (Table 7). However, a study conducted by Chou et al. (2003) in the Bay of Fundy did not detect As and Pb concentrations in American lobster (Table 7).

Presumably, elevated As in American lobster and rock crabs is due to the natural presence of As in rock, soil, and sediments across Nova Scotia (Meunier et al., 2010; Walker and Grant, 2015). These biota species live in direct contact with sediments so contamination in the sediments has a great impact on them (Maharaj and Alkins-Koo, 2007; Hussain and Pandit, 2012). While As in biota tissues could be bioaccumulated over time, the elevated Pb concentrations in rock crab tissues at station N3 was unclear (Fig. 14).

Furthermore, contaminant concentrations (i.e., metals, dioxins and furans, THg) did not exceeded CFIA in blue mussels. Similar patterns were observed in different studies across Nova Scotia, New Brunswick, Gulf of Maine (near the south shore of Nova Scotia) in the United States (Table 7), where metals in mussels were below CFIA guidelines and in some cases were below DLs. Blue mussels are good filter feeders and can filter particles from 2 -5 µm in size (Pruell et al., 1986; Boening, 1999). Low detection of contaminants (i.e., metals, dioxins and furans, THg) in blue mussels collected from along the shoreline of Pictou Harbour indicates that there is limited or negligible contaminant concentrations in seawater.

***Table 7.** Comparison of metals concentrations (mg/kg) in mussel, rock crabs, and lobster tissue by study (adapted from Walker and Grant, 2015).

Location	As	Cd	Cu	Hg	Pb	Zn	Reference
***American lobster tissue** (H. americanus)*							
Northumberland Strait, NS, Canada (DL)(wb) (ww)	4.0-10.0 (2)	0.9-1.4 (0.3)	13-28 (2)	<0.05 (0.05)	<0.4 (0.4)	18-34 (5.0)	Present study
Northumberland Strait, NS, Canada (wb) (ww)	ND-23	ND-0.63	ND-27	ND	ND	ND-42	Maltby et al. (2018 unpublished data)
Isaacs and Country Harbours, NS, Canada (hep)(ww)	5.0-10.0	<0.3	ND	0.06-0.12	<0.5	24.35	Walker and Grant (2015)
Bay of Fundy, NS, Canada	ND	5.1-22.9	10.4-896	ND	ND	27-129	Chou et al. (2000, 2003) *
CFIA	3.5	Nv	nv	0.5	0.5	nv	CFIA (2019)
***Rock crab tissue** (C. irroratus)*							
Northumberland Strait, NS, Canada (DL) (wb) (ww)	2.0-5.0 (2)	0.6-3.9 (0.3)	12-36 (2)	<0.05 (0.05)	<0.4-0.9 (0.4)	24-42 (5.0)	Present study
Sydney Harbour, NS, Canada (hep) (ww)	3.6-15.3	0.5-6.9	9.8-28	<0.01-0.04	<0.18	11.7-28.9	Walker et al. (2013c)
CFIA	3.5	Nv	nv	0.5	0.5	nv	CFIA (2019)
***Blue mussel tissue** (M. edulis)*							
Northumberland Strait, NS, Canada (DL) (ww)	<2.0 (2.0)	<0.3 (0.3)	<2-2 (2.0)	<0.05 (0.05)	<0.4 (0.4)	7-20 (5.0)	Present study
Isaacs and Country Harbours, NS, Canada (ww)	1.3-2.0	0.16-0.19	0.8-6.7	0.02-0.05	0.15-1.31	7.4-11	Walker and Grant (2015)
Seal Harbour, NS, Canada	60-109	ND	ND	ND	ND	ND	Whaley-Martin et al. (2012) *
Sydney Harbour, NS, Canada (ww)	1.5-3.9	0.14-0.29	0.8-1.9	<0.01-0.03	<0.18-0.43	10-24	Walker and MacAskill (2014)
Halifax Harbour, NS, Canada(ww)	1.9-2.5	0.10-0.44	1.5-2.4	0.01-0.04	0.1-2.4	17-41	McCullough et al. (2005)
Dalhousie, NB, Canada (ww)	ND	ND	ND	0.02-1.40	ND	ND	Garron et al. (2005)
Baie des Chaleurs, NB, Canada (ww)	ND	0.55-4.2	0.5-1.1	ND	<2.5-31	4.8-42	Fraser et al. (2011)
Gulf of Maine, United States	ND	1.10-1.31	4.5-9.3	0.11-1.31	1.0-8.3	54-153	McCullough et al. (2005) *
Gulf of Maine, United States	ND	0.10-0.20	0.7-1.3	ND	0.08-0.78	7-13	GMCME (2013) *
CFIA	3.5	Nv	nv	0.5	0.5	nv	CFIA (2019)

Note-*DL- detection limit for present study presented in parentheses; nv- no guideline value; ND- not determined; * data reported did not specify whether wet weight or dry weight ;wb- whole body tissue; hep- hepatopancreases tissue; ww- wet weight; CFIA- Canadian Food Inspection Agency (CFIA, 2019).

Whole-body tissue homogenates of all three species (American lobsters, rock crabs, and blue mussels) were also analyzed for MeHg. There is currently no CFIA guideline for MeHg in fish tissue. For this study, Canadian tissue residue methyl mercury guidelines for the protection of wildlife consumers of aquatic biota (2019) were used for comparison (CCME, 2019b). These MeHg tissue residue guidelines (TRGs) refer to the maximum concentration of chemical substance in the tissues of aquatic biota that is not expected to result in adverse effects to wildlife consumers of the aquatic biota. They are developed to protect wildlife species which are not in direct contact with sediments and usually feed on aquatic animals and plants.

A total of six lobsters (N1, N2, NE1, NE3, N8, NE 8) and four rock crabs (N2, N3, NE1, N2, N8, NE8) were analyzed for MeHg. Four composite samples of blue mussels (from M3, M4, M7, M8) were also analyzed for MeHg. Samples from N1 (37.3 ng/kg), N2 (53.4 ng/kg), NE1 (41.8 ng/kg), NE3 (47.2ng/kg), NE1 (57.5), and N3 (39.5 ng/kg) exceeded the CCME MeHg tissue residue guideline (33.3 ng/kg) (Fig. 15).

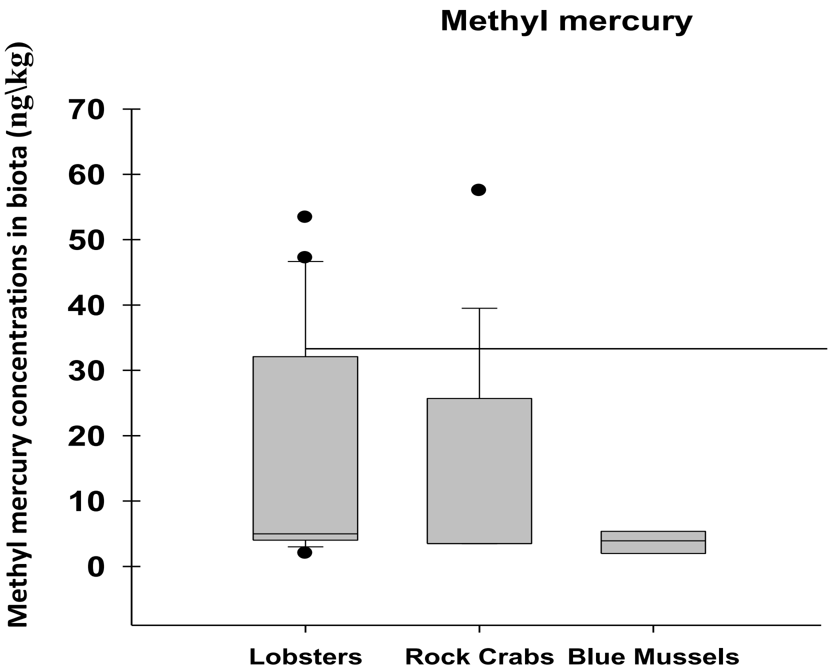

Fig. 15. Box plot representing whole tissue methyl mercury concentrations in lobster (*Homarus americanus)* (*n*=7), rock crabs (*Cancer irroratus)* (*n*=6) and blue mussels (*Mytilus edulis)* (*n*=4). Tissue concentration were expressed in wet weight. Horizontal line represents the methyl mercury guideline by Canadian tissue residue guidelines for the protection of wildlife consumers of aquatic biota (CCME, 2019b).

A number of studies have been conducted to understand the influence of metals, including THg, on exposed biota, but there is a lack of research data on MeHg concentrations in Nova Scotian biota (Stewart, 2019). Further, MeHg has not been tested in BH biota, water, or sediment samples, making it difficult to predict whether the elevation of MeHg is due to migration of contaminants from BH. In the environment, inorganic mercury is regularly methylated into its organic form (MeHg) which can readily bioaccumulate in organisms and is also known to biomagnify through the food chain (Hammerschmidt and Fitzgerald, 2006). Presence of mercury in the environment adjacent to Boat Harbour can possibly have arisen from different sources, for instance the weathering of mercury bearing rocks, fossil fuels, industrial effluents (such as from chlor-akali plants), and atmospheric emissions (UNEP, 2002; Walker, 2016). It is often difficult to attribute environmental MeHg to one or more-point sources. A similar study on Hg near a chlor-alkali plant in Chaleur Bay in New Brunswick, Canada was conducted by Walker (2016), which suggested that there was natural recovery by deposition of new uncontaminated sediments over contaminated strata in the area (Walker, 2016). It is possible that a similar deposition of sediments low in Hg and MeHg could have covered contaminated sediments in this study also. Therefore, it is necessary to have long term monitoring plans in and around BH to examine the effects of remediation activities on concentration of MeHg in the area.

3.6.3 DGTs Metal and THg Concentrations

DGT chelex disc binding gels were analyzed for metals and MFS binding gels were analyzed for THg. DGT chelex disc from station 10 (ESM 10) and MFS disc from station 8 (ESHG 8) were damaged during retrieval and were not analyzed. There are no CCME guidelines for sediment porewater metal concentrations. Therefore, metal concentrations in DGTs from BH were compared to DGTs downstream in the estuary. The concentration of As in the estuary was found to be slightly higher than those in BH with a range of 2.90-4.33 μg/l (Tables 7 and 8). Cd in BH was not detected and was also very low in the estuary. Cu, Cr, Pb and Zn were also found in low concentrations in BH relative to the estuary (Tables 7 and 8). Concentrations of THg in MFX DGTs discs from both BH and the estuary were very low and <DLs at some stations (Table 7 and 8). DGT results indicated that sediment porewater metal concentrations in BH were likely lower than downstream estuary concentrations. Since Cd and THg were not detected in the DGTs, it would appear that these metals are not readily bioavailable for species exposed to sediment porewater.

Table 7. Descriptive statistics of DGT and MFS disc (which represent sediment porewater) metal concentrations (µg/l) from BH (*n*=10).

Metals	Minimum	Maximum	Mean	Std. Deviation	DL
As	1.070	1.600	1.360	0.164	0.200
Cd	0.025	0.025	0.025	0.000	0.050
Cr	1.200	2.000	1.440	0.236	1.000
Cu	0.500	1.300	0.580	0.252	1.000
Hg	0.010	0.030	0.015	0.008	0.020
Pb	0.810	1.65	1.142	0.257	0.200
Zn	5.000	25.000	11.400	8.408	10.000

Table 8. Descriptive statistics of DGT and MFS disc (which represent sediment porewater) metal concentrations (µg/l) from ES (*n*=9).

Metals	Minimum	Maximum	Mean	Std. Deviation	DL
As	2.90	4.33	3.65	0.538	0.200
Cd	0.07	0.12	0.096	0.017	0.050
Cr	1.70	2.10	1.877	0.148	1.000
Cu	0.50	2.10	0.900	0.572	1.000
Hg	0.01	0.01	0.009	0.000	0.020
Pb	1.20	2.15	1.610	0.316	0.200
Zn	5.00	16.00	12.000	3.240	10.000

3.7 Limitations

There are some limitations in this study which should be considered:

1) Due to limited funding and high cost of analysis, only 12 bulk sediment samples were collected and analyzed. In addition, due to rocky substrate, samples from 4 stations (i.e., N5, N6, N7, N8) could not be collected. More samples would have strengthened the statistical power of the study.

2) Only one sample of lobster was collected per station due to restrictions imposed under the DFO scientific fishing licence. More lobster samples would have provided better information on the potential impact of pulp mill effluent on biota and would have also strengthened the statistical power of the study.

3) Lack of CFIA guidelines for some metals (i.e., Cr, Cd, Cu, MeHg) for aquatic biota tissues made it difficult to understand what the detected concentrations of these metals in marine biota mean with respect to human health. In addition, there are a limited number of local studies conducted on metal concentrations in marine biota which made it difficult to get a broader picture of the region.

3.8 Conclusion

The primary objective of this study was to assess the level of contamination in marine sediments and biota of the Northumberland Strait. Therefore, to assess the broader picture of contaminant concentrations across the Northumberland Strait, this study used sediments and three marine species (American lobsters, rock crabs, and blue mussels) from different trophic levels to provide an ecosystem approach. Due to proximity of the Northumberland Strait to the effluent discharge point (estuary), it was expected that the study would find a higher concentration of contaminants in near field stations (N, NE 1-3) relative to far-field stations (N, NE6-8). However, our results provide no evidence of any significant impact on sediments or biota of the Northumberland Strait that is attributable to the industrial effluents. In sediments, all the contaminants (*i.e*. metals, dioxins and furans, mercury) were below the ISQGs and some even below the detection limit. It was interesting to note that the concentrations of metals in sediments were not only found below the CCME ISQGs (CCME, 2019a) but were also below the background concentration range in coastal sediments of Nova Scotia (Loring et al., 2016).

Further, it was assumed that marine biota would be impacted by effluents due to bioaccumulation and biomagnification at different trophic levels. Our results indicate there is no significant impact on Northumberland Strait biota with the exception of As exceedances in lobsters and crab. The source of these As exceedances in the environment is not due to point source releases or industrial activities, but rather, is most likely due to underlying bedrock geology resulting in naturally high As levels in water, sediments and soil across Nova Scotia. MeHg in lobsters and rock crabs were found to be above the prescribed Canadian tissue residue guideline for the protection of wildlife consumers of aquatic biota and are of potential concern. In addition, MeHg can become bioavailable to aquatic biota under certain conditions and may bioaccumulate and biomagnify in marine aquatic food webs. The present study was the first to assess baseline MeHg concentrations in marine biota after 50 years of Boat Harbour effluent discharge.

The final objective of the *Boat Harbour Act* (2015) is to connect Boat Harbour with Northumberland Strait by removing the dam above the estuary. While the volume and surface area of BH will decrease in the absence of the impoundment, there will be an incursion of marine water from Northumberland Strait to Boat Harbour. This incursion may potentially lead to a remobilisation of any mercury present in contaminated sediments that are not removed from Boat Harbour. It has been documented in different studies that flooding changes can lead to remobilisation of THg, and thus increase MeHg in aquatic ecosystem (St Louis et al., 2001, 2004; Roy et al., 2009; Teisserence et al., 2014). Usually, flooding events modify the organic matter dynamics in sediments resulting in sharp increases of TOC in surface sediments which may lead to mobilisation of Hg (Louchouarn et al., 1993). Therefore, it is highly recommended that more detailed investigation of THg and MeHg in and around BH should be conducted.

A strong baseline dataset will help to inform remediation decisions and the monitoring regime during and after remediation activities. Our results clearly indicate that, at present, the Northumberland Strait adjacent to Boat Harbour has similar or less contamination than comparable areas not influenced by Boat Harbour and is therefore not requiring any remediation. However, monitoring should be implemented throughout Boat Harbour remediation to ensure clean-up activities do not inadvertently introduce contaminants known to be resident in the Boat Harbour settling basin. Periodic sediment and same species (American lobsters, rock crabs, and blue mussels) biota sampling are recommended to enable tracking of potential future contamination of the Northumberland Strait, which may occur during or following BH remediation.

Chapter - 4 Conclusions and Recommendation

4.1 Summary of Research

According to the *Boat Harbour Act* (2015), remediation of Boat Harbour (BH) will start after January 31, 2020 (Boat Harbour Act, 2015). The main objective of the *Boat Harbour Act* (2015) is to remediate and return BH to pre-tidal conditions by re-connecting it to the Northumberland Strait (Hoffman et al., 2017a, 2019). In order to have an effective remediation plan, baseline data in BH, its estuary, and the Northumberland Strait receiving environment was necessary. The two objectives of this research were:

1) To assess the level of contamination of metals, dioxins and furans and methyl mercury in sediments and biota of the marine environment of Northumberland Strait; and

2) To prepare the baseline pre-remediation data, which can be used during and after remediation for monitoring purposes.

To achieve these objectives, sediment and American lobsters (*Homarus americanus)*, rock crab (*Cancer irroratus*), and blue mussel (*Mytilus edulis*) sampling was done in May 2018 and July 2019. The samples were analyzed for metals and dioxins and furans (as discussed in chapter- 3). This Chapter provides the summary of key findings and some management-specific recommendations which will help the current and future planning of the BH remediation project.

4.2 Key Findings

1) Sediment concentrations of metals (As, Cd, Cr, THg, Pb, and Zn) and dioxins and furans were below the Canadian Council of Ministers of Environment (CCME) interim sediment quality guidelines. Cd and THg were not detected in sediment samples. These findings were corroborated with results of sediment sampling done by the private consulting firm contracted to perform the site assessment for the Boat Harbour remediation project. Interestingly, sediment metal concentrations in the Northumberland Strait were lower than the background values of sediment metal concentrations at un-impacted sites across Nova Scotia.

2) Concentrations of metals (Cd, Cr, THg, Pb, and Zn) and dioxins and furans in three biota species were below the Canadian Food Inspection Agency guidelines for fish tissue. Arsenic concentrations in lobsters and rock crabs were found to be above the CFIA guidelines. In addition, methyl mercury concentrations in some samples of American lobsters and rock crabs exceeded tissue residue guidelines for the protection of wildlife consumers of aquatic biota.

4.3 Management Implications and Recommendations

4.3.1 Long Term Monitoring Plans

Chemical concentrations (i.e. metals, dioxins and furans and THg) measured in Northumberland Strait sediments in this study were lower than CCME guidelines and BH sediments, demonstrating that the Boat Harbour Treatment Facility achieved its designed objectives of retaining contaminants in BH. The results of the present study will help delineate the boundaries of the BH remediation programs by providing baseline contaminants data during and after remediation.

Additionally, this data will also be helpful if the new effluent pipeline plan proposed by Northern Pulp gets approval (Dillon Consulting Limited, 2019).

The end goal of the Boat Harbour Act is to return the waterbody to a tidally influenced estuary condition by re-connecting it hydraulically to the Northumberland Strait. Therefore, it is very important to have long term monitoring plans for the study area. Currently, the remediation plan for BH has not been definitively addressed, and it is not yet known whether it will be *ex-situ* or *in situ* (dredging, capping). It has been documented that dredging and infilling operations at contaminated sites sometimes lead to major negative sediment disturbances such as resuspension, remobilization and enhanced bioavailability of historical contaminants (Walker et al., 2013a).

Therefore, any negative sediment disturbance in BH during remediation could lead to the migration of contaminants to the Northumberland Strait. Thus, it is recommended that a regular monitoring plan should be developed during and after remediation. Regular water sampling every 2-3 months and annual sediment sampling is recommended during remediation. This will help to measure effectiveness (both positive and negative) of remediation techniques in the area. Long term monitoring is also recommended after remediation which should include periodic sampling of water, sediments, and biota tissue of the area every three years.

4.3.2 More Studies on Metals and MeHg Concentration in Biota in Atlantic Region

Concentrations of metals (except As) and dioxins and furans were found lower than CFIA guidelines. This data is not only useful for remediation plans, but also for the fishing industry of the region. Fishing is the important industry sector for Atlantic Canada. The export of Nova Scotia fish and seafood is valued at $1 billion CAD annually (DFO, 2018; Zhang et al., 2019). The key stakeholder community of this remediation project, Pictou Landing First Nation, are also dependent on the fishing sector. Any exceedance of MeHg in any commercially harvested species in the region could potentially harm the local seafood market, which has a reputation for clean, safe products. In this context, there is a considerable lack of research in the Atlantic region on MeHg concentrations in biota, leading to the recommendation to conduct further studies on biota, particularly focussing on MeHg concentrations to better understand the broader regional picture. Passive techniques like diffusive gradient thin films (DGTs) can be used to estimate the level of contamination in biota, a particularly useful technique in a region where actual biota sampling is not always possible or feasible. DGTs behave as a fish surrogate in water (Ferreira et al., 2013; Bireta, 2015). These studies will help in understanding any potential ecological or human health risk that may be associated with MeHg contamination.

REFERENCES

Abrahim, G. M. S., and Parker, R. J. (2008). Assessment of heavy metal enrichment factors and the degree of contamination in marine sediments from Tamaki Estuary, Auckland, New Zealand. *Environmental Monitoring and Assessment*, *136(1-3*), 227-238.

Adamo, P., Arienzo, M., Imperato, M., Naimo, D., Nardi, G., and Stanzione, D. (2005). Distribution and partition of heavy metals in surface and sub-surface sediments of Naples city port. *Chemosphere, 61,* 800–809.

Ali, M., and Sreekrishnan, T. R. (2001). Aquatic toxicity from pulp and paper mill effluents: a review. *Advances in Environmental Research*, *5*(2), 175-196.

Alimohammadi, M., Tackley, H., Lake, C., Spooner, I., Walker, T.R., Jamieson, R., Gan, C., and Bossy, K. (2019). Effect of different sediment dewatering techniques on subsequent particle sizes in industrial derived effluent. *Canadian Journal of Civil Engineering.*

Al-Farsi, A. H., Sulaiman, H., and Al-Reasi, H. A. (2015). Metal transfer from marine coastal sediment to food chain: evaluating Strombus (Conomurex) persicus for monitoring metal bioaccumulation. *Procedia Environmental Sciences*, *28*, 37-44.

Allen, L. H., Berry, R. M., Fleming, B. I., Luthe, C. E., and Voss, R. H. (1989). Evidence that oil-based additives are an indirect source of the TCDD and TCDF produced in kraft bleach plants. *Chemosphere*, *19*(1-6), 741-744.

Allvaro, N.V., Neto, A.I., Couto, R.P., Azevedo, J.M.N., and Rodrigues, A.S. (2016). Crabs tell the difference Relating trace metal content with land use and land scape attributes. *Chemosphere. 144*, 1377-1383.

Alvarez, D. A. (2010). Guidelines for the use of the semipermeable membrane device (SPMD) and the polar organic chemical integrative sampler (POCIS) in environmental monitoring studies. US Geological Survey, Techniques and Methods, 1, 28.

Amato I. (1993). The crusade against chlorine. *Science 261*:152–154.

Amiard, J.C., Geffard, A., Amiard-Triquet, C., and Crouzet, C. (2007). Relationship between the lability of sediment-bound metals (Cd, Cu, Zn) and their bioaccumulation in benthic invertebrates. *Estuarine, Coastal and Shelf Science.72,* 511–521.

Andrews, S. and Parker, R. (1999). An environmental quality evaluation of Pictou Harbour, Nova Scotia, using caged bivalves, Mytilus edulis. Prepared for the Pictou Harbour Environmental Project, 1-26.

Arntzen, B. C., Brown, G. G., Harrison, T. P., and Trafton, L. L. (1995). Global supply chain management at Digital Equipment Corporation. *Interfaces*, 25(1), 69-93.

ASTM. (2007). Standard Test Method for Particle-Size Analysis of Soils. Retrieved from: https://infostore.saiglobal.com/store/details.aspx/details.aspx?ProductID=834385.

Austin, J. (2015). British Columbia Environmental Laboratory manual. Environmental Monitoring, Reporting and Economics Section, Knowledge Management Branch, B.C. Ministry of Environment, Victoria, BC.

Barrett, T. J., Lowell, R. B., Tingley, M. A., and Munkittrick, K. R. (2010). Effects of pulp and paper mill effluent on fish: a temporal assessment of fish health across sampling cycles. *Environmental Toxicology and Chemistry*, *29*(2), 440-452.

Bárcena, J. F., Claramunt, I., García-Alba, J., Pérez, M. L., and García, A. (2017). A method to assess the evolution and recovery of heavy metal pollution in estuarine sediments: Past history, present situation and future perspectives*. Marine Pollution Bulletin, 124(1),* 421-434.

Bartoli, G., Papa, S., Sagnella, E., and Fioretto, A. (2012). Heavy metal content in sediments along the Calore river: relationships with physical–chemical characteristics. *Journal of Environmental Management*, *95*, S9-S14.

Bender, P., Northuo W., and Shapiro, J. (1981). Practical Modelling for Resource Management, Harvard Business Review, March- April, pp. 163-172.

Bere, T., Dalu, T., and Mwedzi, T. (2016). Detecting the impact of heavy metal contaminated sediment on benthic macroinvertebrate communities in tropical streams. *Science of The Total Environment*, *572*, 147-156.

Biermann, C. J. (1996). *Handbook of pulping and papermaking*. Elsevier.

Bireta, P. J. H. (2015). Application of diffusive gradient in thin-film passive samplers to assess mercury availability and mobility in a freshwater river system (Doctoral dissertation).

Birch, G.F. (2018). A review of chemical-based sediment quality assessment methodologies for the marine environment*. Marine Pollution Bulletin, 133*, 218–232.

Biksham, G., Subramanian, V., and Griken, R.V. (1991). Heavy metal distribution in the Godavari river basin. *Environment Geology and Water Science, 17,* 117-126.

Boat Harbour Act. (2015). An act respecting the cessation of the use of the Boat Harbour Effluent Treatment Facility for the reception and treatment of effluent from the Northern Pulp mill. Bill 89, c. 4, s. 1. Government of Nova Scotia. Retrieved from: https://nslegislature.ca/legc/bills/62nd_2nd/1st_read/b089.html.

Bogdanski, B. E. (2014). The rise and fall of the Canadian pulp and paper sector. The Forestry Chronicle, 90(6), 785-793.

Boening, D. W. (1999). An evaluation of bivalves as biomonitors of heavy metals pollution in marine waters. *Environmental Monitoring and Assessment, 55(3),* 459-470.

Boudet, L. C., Polizzi, P., Romero, M. B., Robles, A., Marcovecchio, J. E., and Gerpe, M. S. (2015). Histopathological and biochemical evidence of hepatopancreatic toxicity caused by cadmium in white shrimp, Palaemonetes argentinus. *Ecotoxicology and Environmental Safety, 113*, 231-240.

Branson, D.R., Takahashi, I.T., Parker, W.M., and Blau, G.E. (1985). Bioconcentration kinetics of 2,3,7,8-tetrachlorodibenzo-p-dioxin in rainbow trout. *Environmental Toxicology and Chemistry 4*:779–788.

Caeiro, S., Costa, M. H., Ramos, T. B., Fernandes, F., Silveira, N., Coimbra, A., and Painho, M. (2005). Assessing heavy metal contamination in Sado Estuary sediment: an index analysis approach. *Ecological Indicators*, *5*(2), 151-169.

Canadian Environmental Protection Act (CEPA). (1999). Retrieved from http://laws-lois.justice.gc.ca/eng/regulations/SOR-92-267/.

Canadian Council of Ministers of the Environment (CCME), 2019. Canadian sediment quality guidelines for the protection of aquatic life probable effect levels (PEL) and the interim sediment quality guidelines (ISQG). In: Canadian Environmental Quality Guidelines. Retrieved from: http://st-ts.ccme.ca/en/index.html.

Canadian Council of Ministers of the Environment (2019a). Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. Retrieved from: http://ceqg-rcqe.ccme.ca/en/index.html#void.

Canadian Council of Ministers of the Environment (2019b). Canadian Tissue residue guidelines for the protection of wildlife consumers of aquatic biota. Retrieved from: http://ceqg-rcqe.ccme.ca/download/en/314.

Canadian Food Inspection Agency (CFIA) 2019. Canadian Guidelines for Chemical Contaminants and Toxins in Fish and Fish Products. Retrieved from: https://www.inspection.gc.ca/food/archived-food-guidance/fish-and-seafood/manuals/standards-and-methods/eng/1348608971859/1348609209602?chap=7#s20c7.

Carey, J.H., Hodson, P.V., Munkittrick, K.R., and Servos, M.R. (1993). Recent Canadian studies on the physiological effects of pulp mill effluent on fish. Report of Environment Canada and Fisheries & Oceans, National Water Research Institute Publ. Rept. 22 p.

Carter, J., Julien, G., Ernst, B., Bernier, F. and Gagne, F. (2004). An assessment of sediment and Blue Mussels from Atlantic Canadian harbours. Environment Canada, EPS Surveillance Report EPS-5-AR-06-01. 34 p.

Campbell, P. G. (1994). Interactions between trace metals and aquatic organisms: a critique of the free-ion activity model. *Metal Speciation and bioavailability,* 45-102.

Campana, O., Simpson, S.L., Spadaro, D.A., and Blasco, J. (2012). Sub-lethal effects of copper to benthic invertebrates explained by sediment properties and dietary exposure. *Environmental Science and Technology. 46*, 6835–6842.

Centre d'expertise en analyse environnementale du Québec (2014).MA 405-C 1.1. Retrieved from: http://www.ceaeq.gouv.qc.ca/methodes/pdf/MA405C11.pdf.

Chapman, P.M., Wang, F., Janssen, C., Persoone, G., and Allen, H. (1998). Ecotoxicology of metals in aquatic sediments: binding and release, bioavailability, risk assessment, and remediation. *Canadian Journal of Fisheries* and *Aquatic* Sciences. 55, 2221–2243.

Chandra, R., and Abhishek, A. (2011). Bacterial decolorization of black liquor in axenic and mixed condition and characterization of metabolites. *Biodegradation, 22(3)*, 603-611.

Chandra, R., Sharma, P., Yadav, S., and Tripathi, S. (2018). Biodegradation of endocrine-disrupting chemicals and residual organic pollutants of pulp and paper mill effluent by bio stimulation. *Frontiers in Microbiology*. https://doi.org/10.3389/fmicb.2018.00960.

Chaudhary, M., and Walker, T. R. (2019). River Ganga pollution: causes and failed management plans (correspondence on Dwivedi et al. 2018. Ganga water pollution: a potential health threat to inhabitants of Ganga basin. Environment International 117, 327–338). *Environment International*, *126*, 202-206.

Chen, C.W., Kao, C.M., Chen, C.F., and Dong, C.D. (2007). Distribution and accumulation of heavy metals in the sediments of Kaohsiung Harbor, Taiwan. *Chemosphere 66*, 1431–1440.

Chen, C.F., Ju, Y.R., Chen, C.W., and Dong, C.D. (2016). Vertical profile, contamination assessment, and source apportionment of heavy metals in sediment cores of Kaohsiung Harbor, Taiwan. *Chemosphere* 165, 67–79.

Cheng, W.H. and Yap, C.K. (2015). Potential human health risks from toxic metals via man-grove snail consumption and their ecological risk assessments in the habitat sediment from Peninsular Malaysia. *Chemosphere, 135*, 156–165.

Chien, L. C., Hung, T. C., Choang, K. Y., Yeh, C. Y., Meng, P. J., Shieh, M. J., and Han, B. C. (2002). Daily intake of TBT, Cu, Zn, Cd and As for fishermen in Taiwan. *Science of the Total Environment*, *285*(1-3), 177-185.

Cipullo, S., Prpich, G., Campo, P., and Coulon, F. (2018). Assessing bioavailability of complex chemical mixtures in contaminated soils: Progress made and research needs. *Science of the Total Environment*, *615*, 708-723.

Colodey, A. G., and Wells, P. G. (1992). Effects of pulp and paper mill effluents on estuarine and marine ecosystems in Canada: a review. *Journal of Aquatic Ecosystem Health, 1*, 201–226.

Connell, D.W. (1989). Biomagnification by aquatic organisms–a proposal. *Chemosphere 19,* 1573–1584. http://dx.doi.org/10.1016/0045-6535(89)90501-8.
Davison, W., & Zhang, H. (2012). Progress in understanding the use of diffusive gradients in thin films (DGT)–back to basics. *Environmental Chemistry, 9(1)*, 1-13.

De Souza Machado, A. A., Spencer, K., Kloas, W., Toffolon, M., and Zarfl, C. (2016). Metal fate and effects in estuaries: a review and conceptual model for better understanding of toxicity. *Science of the Total Environment, 541*, 268-281.

Desaulty, A. M., Méheut, M., Guerrot, C., Berho, C., and Millot, R. (2017). Coupling DGT passive samplers and multi-collector ICP-MS: a new tool to measure Pb and Zn isotopes composition in dilute aqueous solutions. *Chemical Geology, 450*, 122-134.

Dhanakumar, S., Solaraj, G., and Mohanraj, R. (2015). Heavy metal partitioning in sediment and bioaccumulation in commercial fish species of three major reservoirs of river Cauvery delta region, India. *Ecotoxicology and Environmental Safety. 113*, 145–151.

Dillon Consulting Limited. (2000). Boat Harbour Treatment Facility Monitoring Review: Analysis and Future Monitoring Recommendations (Final Report).

Dillon Consulting Limited. (2019). Northern Pulp Nova Scotia Environmental Assessment Registration document replacement effluent treatment facility. Retrieved from: https://novascotia.ca/nse/ea/Replacement_Effluent_Treatment_Facility_Project/.

Du Laing, G., Rinklebe, J., Vandecasteele, B., Meers, E., and Tack, F.M., (2009). Trace metal behaviour in estuarine and riverine floodplain soils and sediments: a review. *Science of Total Environment. 407*, 3972e3985.

Duysak, O., and Ersoy, B. (2014). A biomonitoring study: heavy metals in monodonta turbinate (Mollusca: gastropoda) from iskenderun bay, North-Eastern Mediterranean. *Pakistan Journal of Zoology. 46*, 1317-1322.

EcoMetrix Incorporated. (2007). EEM cycle 4 interpretive report for the Neenah Paper (Pictou mill) facility at New Glasgow, Nova Scotia.

EcoMetrix Incorporated. (2016). EEM cycle 7 interpretive report for the Northern Pulp Nova Scotia Corp. Facility near Pictou, Nova Scotia.

Environment Canada. (1986). Emissions and Trends of Common Air Contaminants in Canada: 1970-1980, Report EPS 7/AP/17, Environment Canada, Ottawa, 104 p.

Environment Canada. (2010). Pulp and Paper Effects Monitoring (EEM) Technical Guidance Document. Retrieved from: https://www.canada.ca/en/environment-climate-change/services/managing-pollution/environmental-effects-monitoring/pulp-paper-technical-guidance.html

Environment Canada. (2013). Pulp and Paper. Retrieved from http://ec.gc.ca/.

Envirosphere Consultants Limited. (1996). Marine environmental survey of the *HMCS Saguenay* artificial reef, Lunenburg, Nova Scotia. Report to Environment Canada, Atlantic Region. 67 p. + appendices.

Ehlers, L.J., and Luthy, R.G. (2003). Contaminant bioavailability in soil and sediment. Improving risk assessment and remediation rests on better understanding bioavailability. *Environment Science and Technology. 37* (15), 295A–302A. http://dx.doi.org/10.1021/ Es032524f.

El Nemr, A., El-Said, G. F., Ragab, S., Khaled, A., and El-Sikaily, A. (2016). The distribution, contamination and risk assessment of heavy metals in sediment and shellfish from the Red Sea coast, Egypt. *Chemosphere*, *165*, 369-380.

Fan, W., Xu, Z., and Wang, W.-X. (2014). Metal pollution in a contaminated bay: relationship between metal geochemical fractionation in sediments and accumulation in a polychaete. *Environmental Pollution.191*, 50-57.

Ferreira, D., Ciffroy, P., Tusseau-Vuillemin, M. H., Bourgeault, A., and Garnier, J. M. (2013). DGT as surrogate of biomonitors for predicting the bioavailability of copper in freshwaters: an ex situ validation study. *Chemosphere, 91(3),* 241-247.

Folke, J. (1996). Future directions for environmental harmonization of pulp mills. In Servos MR, Munkittrick KR, Carey JH, Van Der Kraak GJ, eds, *Environmental Fate and Effects of Pulp and Paper Mill Effluents*. St. Lucie Press, Delray Beach, FL, USA, pp 693-700.

Förstner, U., and Wittmann, G.T.W. (1979). Metal Pollution in the Aquatic Environment. Springer-Verlag, Berlin Heidelberg New York.

Fujita, M., Ide, Y., Sato, D., Kench, P. S., Kuwahara, Y., Yokoki, H., and Kayanne, H. (2014). Heavy metal contamination of coastal lagoon sediments: Fongafale Islet, Funafuti Atoll, Tuvalu. *Chemosphere, 95*, 628-634.

Ganugapenta, S., Nadimikeri, J., Chinnapolla, S. R. R. B., Ballari, L., Madiga, R., Nirmala, K., and Tella, L. P. (2018). Assessment of heavy metal pollution from the sediment of Tupilipalem Coast, southeast coast of India. *International Journal of Sediment Research, 33(3)*, 294-302.

Gao, L., Wang, Z., Li, S., and Chen, J. (2018). Bioavailability and toxicity of trace metals (Cd, Cr, Cu, Ni, and Zn) in sediment cores from the Shima River, South China. *Chemosphere, 192*, 31-42.

Gabarrón, M., Faz, A., Martínez-Martínez, S., Zornoza, R., and Acosta, J. A. (2017). Assessment of metals behaviour in industrial soil using sequential extraction, multivariable analysis and a geostatistical approach. *Journal of Geochemical Exploration, 172*, 174-183.

Garron, C., Gagne F., W., Julien, G., Bernier, M., and Caldwell, C. (2005). Mercury contamination of marine sediments and blue mussels (Mytilus edulis) in the vicinity of a mercury cell chlor-akali plant in Dalhousie, New Brunswick. *Water Quality Research Journal of Canada, 40*,1-15.

GHD. (2018). Phase 2 Environmental Site Assessment. Boat Harbour Remediation Planning and Design Pictou County, Nova Scotia. Submitted to Nova Scotia Lands Inc.

Gibbs, R. J. (1977). Transport phases of transition metals in the Amazon and Yukon Rivers. *Geological Society of America Bulletin, 88(6*), 829-843.

Gray, J.S., and Elliott, M., (2009). Ecology of Marine Sediment, second ed. Oxford University Press Inc., New York (225 pp).

Guan, D. X. (2019). Diffusive Gradients in Thin-Films (DGT): An Effective and Simple Tool for Assessing Contaminant Bioavailability in Waters, Soils and Sediments.

Guérin, T., Chekri, R., Vastel, C., Sirot, V., Volatier, J.L., Leblanc, J.C., and Noël, L. (2011). Determination of 20 trace elements in fish and other seafood from the French market. *Food Chemistry, 127*, 934-942.

Hahladakis, J., Smaragdaki, E., Vasilaki, G., and Gidarakos, E. (2013). Use of sediment quality guidelines and pollution indicators for the assessment of heavy metal and PAH contamination in Greek surficial sea and lake sediments. *Environmental Monitoring and Assessment, 185(3),* 2843-2853.

Hakeem, A. S., & Smita, B. (2010). Heavy metal reduction of pulp and paper mill effluent by indigenous microbes. *Asian Journal of Experimental Biological Sciences, 1(1*), 201-203.

Hammerschmidt, C.R., and Fitzgerald, W.F. (2006). Bioaccumulation and Trophic Transfer of Methylmercury in Long Island Sound. Arch. *Environmental Contamination and Toxicology*, *51*, 416–424.

Hewitt, L. M., Smyth, S. A. M., Dubé, M. G., Gilman, C. I., and MacLatchy, D. L. (2002). Isolation of compounds from bleached kraft mill recovery condensates associated with reduced levels of testosterone in mummichog (Fundulus heteroclitus*). Environmental Toxicology and Chemistry: An International Journal, 21(7*), 1359-1367.

Hewitt, L. M., Kovacs, T. G., Dubé, M. G., MacLatchy, D. L., Martel, P. H., McMaster, M. E., and Van Der Kraak, G. J. (2008). Altered reproduction in fish exposed to pulp and paper mill effluents: roles of individual compounds and mill operating conditions. *Environmental Toxicology and Chemistry: An International Journal*, *27(3),* 682-697.

Higgins, M. J., Chen, Y. C., Yarosz, D. P., Murthy, S. N., Maas, N. A., Glindemann, D., and Novak, J. T. (2006). Cycling of volatile organic sulfur compounds in anaerobically digested biosolids and its implications for odors. *Water Environment Research, 78(3*), 243-252.
Hobbie, J.E. (2000). Estuarine Science: A Synthetic Approach to Research and Practice. Island Press, Washington, DC.

Hoffman, E., Bernier, M., Blotnicky, B., Golden, P. G., Janes, J., Kader, A., and Walker, T. R. (2015). Assessment of public perception and environmental compliance at a pulp and paper facility: a Canadian case study. *Environmental Monitoring and Assessment*, *187*, 1–13.

Hoffman, E., Lyons, J., Boxall, J., Robertson, C., Lake, C. B., and Walker, T. R. (2017a). Spatiotemporal assessment (quarter-century) of pulp mill metal(loid) contaminated sediments to inform remediation decisions. *Environmental Monitoring and Assessment*, 189-257.

Hoffman, E., Guernsey, J., Walker, T., Kim, J., Sherren, K., and Andreou, P. (2017b). Pilot study investigating ambient air toxics emissions near a Canadian kraft pulp and paper facility in Pictou County, Nova Scotia. *Environmental Science and Pollution Research International, 24*(25), 20685-20698.

Hoffman, E., Alimohammadi, M., Lyons, J., Davis, E., Walker, T. R., and Lake, C. B. (2019). Characterization and spatial distribution of organic-contaminated sediment derived from historical industrial effluents. *Environmental Monitoring and Assessment, 191(9*), 590.

Hodkinson, I. D., and Jackson, J. K. (2005). Terrestrial and aquatic invertebrates as bioindicators for environmental monitoring, with particular reference to mountain ecosystems. *Environmental Management*, *35*(5), 649-666.

Hussain, Q.A., and Pandit, A.K. (2012). Macroinvertebrates in streams: a review of some ecological factors. *International Journal of Fisheries and Aquaculture* 4 (7), 114–123.

Interstate technology regulatory council. (2019). Contaminated Sediments Remediation. Retrieved from: https://www.itrcweb.org/contseds_remedy-selection/Default.htm#3%20Monitored%20Natural%20Recovery.html.

Jamshidi, S., and Bastami, K.D., (2016). Metal contamination and its ecological risk assessment in the surface sediments of Anzali wetland, Caspian Sea. *Marine Pollution Bulletin*.*113,* 559–565.

Jain, R. (2015). Environmental impact of mining and mineral processing: management, monitoring, and auditing strategies. Butterworth-Heinemann.

JWEL and Beak Consultants (1992). An investigation of sediment characteristics at Boat Harbour Treatment Facility. Report to Nova Scotia Department of Supply and Services, NSDSS Project. No. 8109.

JWEL and Beak Consultants (1993). A supplementary study to assess the sediment characteristics of the estuary at the Boat Harbour Treatment Facility.

JWEL. (1996). First cycle aquatic environmental effects monitoring program Boat Harbour wastewater treatment facility. Report to Environment Canada, April 1996.

JWEL (1999). Sediment chemistry and biotoxicity at the BHTF Stabilization Lagoon. Report to NSTPW. Report No. 13248.

JWEL (2001). Sediment sampling BHTF stabilization lagoon. Report to NSTPW, Project No. NSD 15200.

JWEL (2005). Sediment sampling BHTF stabilization lagoon. Report to NSTPW. Project No. NSD 17324–7.

Kamali, M., and Khodaparast, Z. (2015). Review on recent developments on pulp and paper mill wastewater treatment. *Ecotoxicology and environmental safety, 114*, 326-342.

Kang, X.M., Song, J.M., Yuan, H.M., Duan, L.Q., Li, X.G., Ning, L., Liang, X.M., and Qu, B.X. (2017). Speciation of heavy metals in different grain sizes of Jiaozhou Bay sediments: bioavailability, ecological risk assessment and source analysis on a centennial time- scale*. Ecotoxicology and Environmental Safety. 143*, 296-306.

Kakkar, P., and Jaffery, F.N. (2005) Biological markers for metal toxicity. Journal of *Environmental Toxicology* and *Pharmacology, 19*:335–349.

Kennish, M.J. (1991). Ecology of Estuaries: Anthropogenic Effects. CRC Press, Florida.

Kilgour, B. W., Dubé, M.G., Hedley, K., Portt, C.B., and Munkittrick, K. R. (2007). Aquatic environmental effects monitoring guidance for environmental assessment practitioners. *Environmental Monitoring and Assessment, 130*, 423–436.

Kincaid, J. (Ed.). (1998). North American Pulp and Paper Fact Book. Miller Freeman Publications, San Francisco, California.

Kimbrough, K. L., Lauenstein, G. G., Christensen, J. D., and Apeti, D. A. (2008). An assessment of two decades of contaminant monitoring in the Nation's Coastal Zone.

Kringstad, K. P., and Lindström, K. (1984). Spent liquors from pulp bleaching. *Environmental Science and Technology*, *18*(8), 236A-248A.

La Colla, N.S., Botté, S.E., and Marcovecchio, J.E. (2018). Metals in coastal zones impacted with urban and industrial wastes: insights on the metal accumulation pattern in fish species. *Journal of Marine System. 181*, 53–62.

Lavery, J.T., Kemper, M.C., Sanderson. K., Schultz, G.C., Coyle. P., James. G., Mitchell. G.J., and Seuront, L. (2009). Heavy metal toxicity of kidney and bone tissues in South Australian adult bottlenose dolphins (Tursiops aduncus). *Marine Environmental Research, 67*:1–7.

LEM Laboratory. (1994). Boat Harbour lobster taint study.

Li, Q., Wu, Z., Chu, B., Zhang, N., Cai, S., and Fang, J. (2007). Heavy metals in coastal wetland sediments of the Pearl River Estuary, China*. Environmental Pollution, 149(2*), 158-164.

Liu, J., Cao, L., and Dou, S. (2017). Bioaccumulation of heavy metals and health risk assessment in three benthic bivalves along the coast of Laizhou Bay, China. *Marine Pollution Bulletin*. *117*, 98–110.

Liu, J. J., Ni, Z. X., Diao, Z. H., Hu, Y. X., and Xu, X. R. (2018). Contamination level, chemical fraction and ecological risk of heavy metals in sediments from Daya Bay, South China Sea. *Marine Pollution Bulletin, 128*, 132-139.

Lin, J. G., and Chen, S. Y. (1998). The relationship between adsorption of heavy metal and organic matter in river sediments. *Environment International, 24(3),* 345-352.

Long, E.R., and Morgan, L.G. (1990). The potential for biological effects of sediment sorbed contaminants tested in the national status and trends program. In: NOAA Technical Memorandum NOS OMA 52, Seattle, WA, (175pp.).

Lopes, M. L., Rodrigues, A. M., and Quintino, V. (2014). Ecological effects of contaminated sediments following a decade of no industrial effluents emissions: The Sediment Quality Triad approach*. Marine Pollution Bulletin, 87(1-2),* 117-130.

Loring, D.H., Rantala, R.T.T. and Milligan, T.G. (1996). Metallic contamination in the sediments of coastal embayment's of Nova Scotia. *Canadian Bulletin Fish Aquatic Science.* 2111 (viii. 268 pp).

Louchouarn. P., Lucotte, M., Mucci, A., and Pichet, P. (1993) Geochemistry of mercury in two hydroelectric reservoirs in Quebec, Canada. *Canadian Journal of Fisheries and Aquatic Science, 50,* 269–281.

Luthe C.E., Fleming B.I., Berry R.M., Allen L.H., and Voss R.H. (1988). Some new insights into the origins of dioxins formed during chemical pulp bleaching. *Pulp Paper Canada. 89*:151–167.

Luoma, S.N. and Rainbow, P.S. (2008). Metal Contamination in Aquatic Environments: *Science and Lateral Management*. Springer, Berlin, p. 573.

Machado, A.A.D.S., Spencer, K., Kloas, W., Toffolon, M., and Zarfl, C. (2016). Metal fate and effects in estuaries: a review and conceptual model for better understanding of toxicity. *Science of Total Environment. 541*, 268–281.

MacDonald, D.D., Carr, R.S., Calder, F.D., Long, E.R., and Ingersoll, G.G. (1996). Development and evaluation of sediment quality guidelines for Florida coastal waters. *Ecotoxicology 5*, 253–278.

Maanan, M. (2008). Trace metal contamination of marine organisms from the Moroccan North Atlantic coastal environments. *Environmental Pollution. 153* (1), 176–183.

Maanan, M., Saddik, M., Maanan, M., Chaibi, M., Assobhei, O., and Zourarah, B. (2015). Environmental and ecological risk assessment of heavy metals in sediments of Nador lagoon, Morocco. *Ecological Indicators, 48*, 616-626.

Maharaj, L. and Alkins-Koo, M. (2007). Use of benthic macroinvertebrates to assess anthropogenic impacts in the rivers of Trinidad and Tobago. Report to the Environmental Management Authority, Trinidad and Tobago.

Martel, A., M'Barek, W., and D'Amours, S. (2005). International factors in the design of multinational supply chains: the case of Canadian pulp and paper companies. *Document de travail DT-2005-AM-3, Centor, Université Laval*, *10*, 85-96.

Martin, N., Anglani, N., Einstein, D., Khrushch, M., Worrell, E., and Price, L. K. (2000). Opportunities to improve energy efficiency and reduce greenhouse gas emissions in the US pulp and paper industry.

Martincic, D., Kwokal, Z., and Branica, M. (1990). Distribution of zinx, lead, cadmium, and copper between different size fractions of sediments. *Science of Total Environment, 95*, 201-215.

Marziali, L., Rosignoli, F., Drago, A., Pascariello, S., Valsecchi, L., Rossaro, B., and Guzzella, L. (2017). Toxicity risk assessment of mercury, DDT and arsenic legacy pollution in sediments: A triad approach under low concentration conditions. *Science of the Total Environment*, *593*, 809-821.

Maruya, K.A., Lao, W., Tsukada, D., and Diehl, D.W. (2015). A passive sampler based on solid phase microextraction (SPME) for sediment-associated organic pollutants: comparing freely dissolved concentration with bioaccumulation. *Chemosphere 137*: 192–197. http://dx.doi.org/10.1016/j.

Maltby, L., Blake, N., Brock, T.C.M., and Van den Brink, P.J. (2005). Insecticide species sensitivity distributions: importance of test species selection and relevance to aquatic ecosystems. *Environment Toxicology Chemistry. 24*(2). Wiley Periodicals, Inc., pp. 379–388.

Maltby, E., Williams, J., Russel, K., and Cogger, A. (2018). Assessment of American lobsters (*Homarus americanus*); a baseline survey for Boat Harbour remediation. (Unpublished data).

McLeay and Associates Ltd. (1987). Aquatic toxicity of pulp and paper mill effluent: A review. EPS 4/PF/1. Ottawa, Ontario: Environment Canada.

McMaster, M. E., Van Der Kraak, G. J., Portt, C. B., Munkittrick, K. R., Sibley, P. K., Smith, I. R., and Dixon, D. G. (1991). Changes in hepatic mixed-function oxygenase (MFO) activity, plasma steroid levels and age at maturity of a white sucker population (Catostomus commersoni) exposed to bleached kraft pulp mill effluent. *Aquatic Toxicology. 21*:199–218.

McMaster, M. E., Mark Hewitt, L., and Parrott, J. L. (2006). A decade of research on the environmental impacts of pulp and paper mill effluents in Canada: field studies and mechanistic research. *Journal of Toxicology and Environmental Health, Part B*, *9*(4), 319-339.

Menon, M.G., Gibbs, R.J., and Phillips, A. (1998). Accumulation of muds and metals in the Hudson River estuary turbidity maximum*. Environmental Geology. 34* (2–3), 214–222.

Milligan, T. G., and Law, B. A. (2013). Contaminants at the sediment–water interface: implications for environmental impact assessment and effects monitoring. *Environmental Science & Technology, 47(11*), 5828-5834.

Millennium Ecosystem Assessment. (2005). Ecosystems and Human Well-being:Wetlands and Water Synthesis. World Resources Institute, Washington, DC. USA.

Morel, J., and Hering, J. (1993). Principles and Applications of Aquatic Chemistry. John Wiley and Sons Inc., New York, USA (588 p).

Mukwaturi, M., and Lin, C. (2015). Mobilization of heavy metals from urban contami- nated soils under water inundation conditions. *Journal of Hazard Material*. *285*, 445e452.

Mu¨ller, G. (1969). Index of geoaccumulation in sediments of the Rhine River. *The Journal of Geology*, *2,* 108–118.

Munkittrick, K. R., Portt, C. B., Van Der Kraak, G. J., Smith, I. R., and Rokosh, D. A. (1991). Impact of bleached kraft mill effluent on population characteristics, liver MFO activity, and serum steroid levels of a Lake Superior white sucker (Catostomus commersoni) population. *Canadian Journal of Fisheries and Aquatic Science .48*:1371–1380.

Munkittrick, K.R., Van Der Kraak, G.J., McMaster, M.E., and Portt, C.B. (1992). Response of hepatic mixed function oxygenase (MFO) activity and plasma sex steroids to secondary treatment and mill shutdown. *Environmental Toxicology and Chemistry.11*:1427–1439

Munkittrick, K. R., McMaster, M. E., McCarthy, L. H., Servos, M. R., and Van Der Kraak, G. J. (1998). An overview of recent studies on the potential of pulp-mill effluents to alter reproductive parameters in fish. *Journal of Toxicology and Environmental Health, Part B Critical Reviews*, *1*(4), 347-371.

Munkittrick, K. R., McMaster, M. E., and Servos, M. R. (2013). Detection of reproductive impacts of effluents from pulp and paper mills shifts in issues and potential causes. *Environmental Toxicology and Chemistry*, *32*(4), 729-731.

Murray, W. (1992). Canada Library of Parliament. Research Branch, & Depository Services Program. Pulp and paper: The reduction of toxic effluents (Background paper (Canada. Library of Parliament. Research Branch BP-292E). Ottawa]: Library of Parliament, Research Branch.

Natural Resource Canada. (2019). Forest Fact book 208-2019. Retrieved from: http://publications.gc.ca/collections/collection_2019/rncan-nrcan/Fo1-17-2019-eng.pdf.

National Oceanic and Atmospheric Administration's (NOAA) (2019). Sediment Quality Guidelines developed for National Status and Trends Program. Retrieved from: http://www.coastalscience.noaa.gov/publications/handler.aspx?key=1527.

Oakes, K. D., Hewitt, L. M., McMaster, M. E., Wood, C., Munkittrick, K. R., and Van Der Kraak, G. J. (2005). Oxidative stress and sex steroid levels in fish following short-term exposure to pulp-mill effluents. Journal of Toxicology and Environmental Health, Part A, 68(4), 267-286.

Owens, J. W. (1991). The hazard assessment of pulp and paper effluents in the aquatic environment: a review. *Environmental Toxicology and Chemistry: An International Journal*, *10*(12), 1511-1540.

Onder, S., and Dursun, S. (2006). Air borne heavy metal pollution of Cedrus libani (A. Rich.) in the city centre of Konya (Turkey). *Atmospheric Environment. 40*, 1122e1133.

Ololade, I.A., Lajide, L., Olumekunc, V.O., Ololaded, O.O., and Ejelonu, B.C. (2011). Influence of diffuse and chronic metal pollution in water and sediments on edible seafoods within Ondo oil-polluted coastal region, Nigeria. *Journal of Environmental Science and Health, 46*, 898–908.

Paramasivam, K., Ramasamy, V., and Suresh, G. (2015). Impact of sediment characteristics on the heavy metal concentration and their ecological risk level of surface sediments of Vaigai river, Tamilnadu, India. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 137, 397-407.

Parizanganeh, A. (2008). Grain size effect on trace metals in contaminated sediments along the Iranian coast of the Caspian Sea. In Proceedings of Taal2007: The 12th World Lake Conference (Vol. 329, p. 336).

Peck, V., and Daley, R. (1994). Toward a "greener" pulp and paper industry. *Environmental Science and Technology,* (12), 524a-527a.

Pictou Landing Native Women's Group, Castleden, H., Lewis, D., Jamieson, R., Gibson, M., Rainham, D., Russell, R., Martin, D., and Hart, C. (2016). Our Ancestors are in our land, water, and air: a two-eyed seeing approach to researching environmental health concerns with Pictou Landing First Nation—Final Report. p. 117.

Pinheiro, M.A.A., Silva, P.P.G., Duarte, L.F.A., Almeida, A.A., and Zanotto, F.P. (2012). Accumulation of six metals in the mangrove crab Ucides cordatus (Crustacea: ucididae) and its food source, the red mangrove Rhizophora mangle. *Ecotoxicology and Environmental Safety, 81.*114-121.

Pruell, R. J., Lake, J. L., Davis, W. R., and Quinn, J. G. (1986). Uptake and depuration of organic contaminants by blue mussels (Mytilus edulis) exposed to environmentally contaminated sediment. *Marine Biology, 91(4),* 497-507.

Pokhrel, D., and Viraraghavan, T. (2004). Treatment of pulp and paper mill wastewater—a review. *Science of the Total Environment, 333*(1-3), 37-58.

Pulp and paper effluent regulations (PPER). 1992. Pulp and paper effluent regulations. Fisheries Act SQR/92–69. P.C. 1992–961.

Qiu, Y.W. (2015). Bioaccumulation of heavy metals both in wild and mariculture food chains in Daya Bay, South China. *Estuarine, Coastal and Shelf Science*. 163 (2015) 7–14.

Quevauviller, P., Rauretb, G., Tipez-SBnchezb, J.F., Rubiob, R., Ure, A., and Muntaud, H. (1997). Certification of trace metal extractable contents in a sediment reference material (CRM 601) following a three-step sequential extraction procedure. *Science of Total Environment. 205*, 223–23.

Rasmussen, J. J., Wiberg-Larsen, P., Baattrup-Pedersen, A., Cedergreen, N., McKnight, U. S., Kreuger, J., and Friberg, N. (2015). The legacy of pesticide pollution: An overlooked factor in current risk assessments of freshwater systems. *Water Research*, 84, 25-32.

Rainbow, P. S. (1995). Biomonitoring of heavy metal availability in the marine environment. *Marine Pollution Bulletin*, *31*(4-12), 183-192.

Rai, N., and Pal, A. (2002). Health hazards of heavy metals. Enviro News ISEB India vol 8 No. 1. In: International conference on plants and environmental pollution (ICPEP-2). Proceedings of the 2nd international conference on plants and environmental pollution, Lucknow, India, 4–9 Feb 2002. http://isebindia.com/issuewise.html .

Raknuzzaman, M., Ahmed, M. K., Islam, M. S., Habibullah-Al-Mamun, M., Tokumura, M., Sekine, M., and Masunaga, S. (2016). Trace metal contamination in commercial fish and crustaceans collected from coastal area of Bangladesh and health risk assessment. *Environmental Science and Pollution Research*, *23*(17), 17298-17310.

Reid, D. S. (1989). Pictonians, pulp mill, and pulmonary diseases. *Nova Scotia Medical Journal*, 68, 146–148.

Roach, B., and Walker, T. R. (2017). Aquatic monitoring programs conducted during environmental impact assessments in Canada: preliminary assessment before and after weakened environmental regulation. *Environmental Monitoring and Assessment*, 189(3), 109.

Ridgway, J., and Shimmield, G. (2002). Estuaries as Repositories of Historical Contamination and their Impact on Shelf Seas. *Estuarine, Coastal and Shelf Science, 55*(6), 903-928.

Riba, I., DelValls, T. A., Forja, J. M., and Go´mez-Parra, A. (2002). Influence of the Aznalco´llar mining spill on the vertical distribution of heavy metals in sediments from the Guadalquivir Estuary (SW Spain). *Marine Pollution Bulletin, 44*, 39–47.

Ruello, M. L., Sileno, M., Sani, D., and Fava, G. (2008). DGT use in contaminated site characterization. The importance of heavy metal site specific behaviour. *Chemosphere, 70(6),* 1135-1140.

Rosi-Marshall, E.J., and Wallace, J.B. (2002). Invertebrate food webs along a stream resource gradient. *Freshwater Biology. 47* (1), 129–141.

Romo, J., Chaudhary, M., and Walker, T. R. (2019). Baseline assessment of contaminants in marine biota prior to remediation of industrial effluent impacted sediments in a former tidal estuary in Nova Scotia, Canada. *Marine Pollution Bulletin*, *145*, 641-648.

Roy. V., Amyot. M., and Carignan. R. (2009). Beaver ponds increase methylmercury concentrations in Canadian shield streams along vegetation and pond-age gradients. *Environment Science and Technology. 43,*5605–5611.

Rubio, B., Nombela, M. A., and Vilas, F. (2000). Geochemistry of major and trace elements in sediments of the Ria de Vigo (NW Spain): an assessment of metal pollution. *Marine pollution bulletin*, *40*(11), 968-980.

Rule, J. H. (1986). Assessment of trace element geochemistry of Hampton Roads Harbor and Lower Chesapeake Bay area sediments. *Environmental Geology and Water Sciences, 8(4)*, 209-219.

Runck, C. (2007). Macroinvertebrate production and food web energetics in an industrially contaminated stream. *Ecological Application 17 (*3), 740–753.

Saltman, D. (1978). Paper basics: Forestry, Manufacture, Selection, Purchasing, Mathematics, and Metrics, Recycling. Van Nostrand Reinhold Company, San Franciso, CA.

Salt, D.E., Prince, R.C., Pickering, I.J., and Raskin, I. (1995). Mechanisms of cadmium mobility and accumulation in Indian mustard. *Plant Physiology. 109*, 1427-1433.

Santos, I.R., Silva-Filho, E.V., and Schaefer, C.E.G.R. (2005). Heavy metal contamination in coastal sediments and soils near the Brazilian Antarctic Station, King George Island. *Marine Pollution Bulletin. 50*, 185–194.

Sandström, O., Neuman, E., and Karås, P. (1988). Effects of a bleached pulp mill effluent on growth and gonad function in Baltic coastal fish. *Water Science and Technology*, *20*(2), 107-118.

Saher, N. U., and Siddiqui, A. S. (2019). Occurrence of heavy metals in sediment and their bioaccumulation in sentinel crab (Macrophthalmus depressus) from highly impacted coastal zone. *Chemosphere*, *221*, 89-98.

Seakem Oceanography Ltd. (1990). Preliminary environmental profile – Pictou Harbour. A report to Environment Canada Conservation and Protection. Protect No. 01077.

SeaTech Ltd. (1996). Review of mercury levels in soils of Nova Scotia compared with Boat Harbour.

Servos, M. R. (1996). Environmental fate and effects of pulp and paper: mill effluents. Boca Raton: CRC Press.

Sinclair, W.F. (1990). Controlling Pollution from Canadian Pulp and Paper Manufacturers: A Federal Perspective, Environment Canada, Ottawa, 360 p.

Singh, A.K., and Chandra, R. (2019). Pollutants released from the pulp paper industry: Aquatic toxicity and their health hazards. *Aquatic Toxicology, 211*, 202-216.

Smook, G.A. (1992). Handbook for Pulp and Paper Technologist. Angus Wilde Publications, Vancouver, Bellingham.

Soskolne, C. L., and Sieswerd, L. E. (2010). Cancer risk associated with pulp and paper mills: a review of occupational and community epidemiology. Chronic Diseases and Injuries in Canada, 29.

Södergren A. (1989). Biological effects of bleached pulp mill effluents. National Swedish Environmental Protection Board, Final Report 3558. Stockholm, Sweden.

Södergren, A. (1992). Environmental fate and effects of bleached pulp mill effluents. Report 4031. In *Proceedings, SEPA Conference, Saltsjöbaden, Sweden, November* (pp. 19-21).

Spencer, K.L., MacLeod, C.L., Tuckett, A., and Johnson, S.M. (2006). Source and distribution of tracemetals in the Medway and Swale estuaries, Kent. *Marine Pollution Bulletin. 52*, 226–231.

Spooner, I., and Dunnington, D. (2016). Boat Harbour gravity core sediment survey. Draft report to Nova Scotia Lands Inc. pp. 15.

Sprague, J.B., and Colodey, A.J. (1989). Toxicity to aquatic organisms of organochlorine substances in kraft mill effluents. Unpublished. Report for Renewable Resources, Extraction and Processing Division, Industrial Programs Branch, Conversation and Protection, Environment Canada, June 1989. 53 p.

St-Jean, S.D., Courtenay, S.C., and Parker, R.W. (2003). Immunomodulation in Blue Mussels (*Mytilus edulis*) exposed to a pulp and paper mill effluent in eastern Canada. *Water Quality Research Journal of Canada*, 38(4), 647-666.

Stankovic, S., Kalaba, P., and Stankovic, A. R. (2014). Biota as toxic metal indicators. *Environmental Chemistry Letters*, *12*(1), 63-84.

Stantec. (2004). Cycle 3 environmental effects monitoring interpretive report for the Kimberly-Clark Nova Scotia Mill at New Glasgow. Report to Kimberley Clark, New Glasgow.

Stantec (2013). Sediment metals chemistry. (Unpublished raw data). Project No: 12141056.

Stantec (2016). Final report: Geotechnical and contaminant assessment. Report to Nova Scotia Lands Inc. File No: 121413919.

Stewart, P.L., Kendall, V.J., and Breeze, H.J. (2019). Marine Environmental Contaminants in the Scotian Shelf Bioregion: Scotian Shelf, Bay of Fundy and Adjacent Coastal and Offshore Waters— 1995-present (Dartmouth, Nova Scotia: Bedford Institute of Oceanography).

St. Louis V.L., Rudd J.W.M, Kelly C.A., Hall B.D., Rolfhus K.R., Scott K.J., Lindberg. S., and Dong, W. (2001). Importance of the forest canopy to fluxes of methyl mercury and total mercury to boreal ecosystems. *Environment Science and Technology*, *35*,3089–3098.

St. Louis V.L., Rudd J.W.M, Kelly C.A., Bodaly R.A., Paterson M.J., Beaty K.G., Hesslein R.H., Heyes. A., and Majewski. A.R. (2004). The rise and fall of mercury methylation in an experimental reservoir. *Environment Science and Technology, 38*,1348–1358.

Stoffers, P., Glasby, G. P., Wilson, C. J., Davis, K. R., and Watter,P. (1986). Heavy metal pollution in Wellington Harbour. *New Zealand Journal of Marine and Freshwater Research, 20*, 495–512.

Swartz, R.C. (1999). Consensus sediment quality guidelines for PAH mixtures. *Environmental Toxicology and Chemistry*, *18*, 780–787.

Sunito, L.R., Shiu, W.Y., and Mackay, D. (1988). A review of the nature and properties of chemicals present in pulp mill effluents. *Chemosphere, 7*, 1249-1290.
Sun, Q., Ding, S.M., Wang, Y., Xu, L., Wang, D., Chen, J., and Zhang, C.S. (2016). In-situ characterization and assessment of arsenic mobility in lake sediments. *Environmental Pollution. 214*, 314–323.

Szabó, L., Soria, A., Forström, J., Keränen, J. T., and Hytönen, E. (2009). A world model of the pulp and paper industry: demand, energy consumption and emission scenarios to 2030. *Environmental Science and Policy*, *12*, 257–269.

Szefer, P., Kim, B. S., Kim, C. K., Kim, E. H., and Lee, C. B. (2004). Distribution and coassociations of trace elements in soft tissue and byssus of Mytilus galloprovincialis relative to the surrounding seawater and suspended matter of the southern part of the Korean Peninsula. *Environmental Pollution*, *129*(2), 209-228.

Taylor, R. (2015). Boat Harbour cleanup far from simple | The Chronicle Herald.
Teisserenc, R., Lucotte. M., Canuel. R., Moingt. M., and Obrist. D. (2014). Combined dynamics of mercury and terrigenous organic matter following impoundment of Churchill Falls Hydroelectric Reservoir, Labrador. *Biogeochemistry*,118,21–34.

Thornton, J. (1991). The Product is the Poison: The Case for a Chlorine Phase-Out (Washington, D.C.: Greenpeace, 1991).

Toczyłowska, M. R. (2017). Limits and perspectives of pulp and paper industry wastewater treatment–A review. *Renewable and Sustainable Energy Reviews, 78,* 764-772.

Tuikka, A.I., Schmitt, C., Höss, S., Bandow, N., von der Ohe, P.C., and Zwart, D. (2011). Toxicity assessment of sediments from three European river basins using a sediment contact test battery. *Ecotoxicology Environment and Safety, 74 (1),* 123–131 (Jan).

Uğurlu, M., Gürses, A., Doğar, Ç., and Yalçın, M. (2008). The removal of lignin and phenol from paper mill effluents by electrocoagulation. *Journal of Environmental Management*, 87(3), 420-428.

United States Environmental Protection Agency (USEPA) (1998). Department of Agriculture, Clean Water Action Plan: Restoring and Protecting America's Waters. EPA-840-R-98-001. Washington.

United Nations Environment Programme (UNEP) (1995). UNEP/ GC.18/32.

USEPA (1994). Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS Retrieved from: https://www.epa.gov/sites/production/files/2015-08/documents/method_1613b_1994.pdf.

USEPA (1998a). US-EPA SW 846 6020A. Retrieved from: https://www.epa.gov/sites/production/files/2015-07/documents/epa-6020a.pdf.

USEPA (1998b). Methyl Mercury in Water by Distillation, Aqueous Ethylation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry. Retrieved from: https://www.epa.gov/sites/production/files/2015-08/documents/method_1630_1998.pdf.

United States Geological Survey (2000). Mercury in the Environment. Retrieved from: https://www2.usgs.gov/themes/factsheet/146-00/.

USEPA (2014). Method 6020b inductively coupled plasma—mass spectrometry. Retrieved from: https://www.epa.gov/sites/production/files/2015-12/documents/6020b.pdf

USEPA (2019). Acid digestion of sediments, sludges, and soils. Retrieved from: https://www.epa.gov/sites/production/files/2015-06/documents/epa-3050b.pdf

US-EPA (2019). Determination of the biologically relevant sampling depth for the terrestrial and aquatic ecological risk assessments (Final Report). Retrieved from: https://cfpub.epa.gov/ncea/erasc/recordisplay.cfm?deid=310058

Vannote, R.L., Minshall, G.W., Cummins, K.W., Sedell, J.R., and Cushing, C.E. (1980). The river continuum concept. *Canadian Journal of Fisheries and Aquatic. Science. 37* (1), 130–137.

Verma, N., and Sharma, R. (2017). Bioremediation of toxic heavy metals: a patent review. *Recent Patents on Biotechnology, 11(3*), 171-187.

Vezzone, M., Cesar, R., de Souza Abessa, D. M., Serrano, A., Lourenço, R., Castilhos, Z., and Polivanov, H. (2019). Metal pollution in surface sediments from Rodrigo de Freitas Lagoon (Rio de Janeiro, Brazil): Toxic effects on marine organisms. *Environmental Pollution*, *252*, 270-280.

Velez, C., Pires, A., Sampaio, L., Cardoso, P., Moreira, A., Leandro, S., Figueira, E., Soares, A.M.V.M., and Freitas, R. (2015). The use of Cerastoderma glaucum as a sentinel and bioindicator species: take-home message. *Ecological Indicator. 62* https://doi.org/ 10.1016/j.ecolind.2015.10.051.

Wang, C., Liu, S., Zhao, Q., Deng, L., and Dong, S. (2012). Spatial variation and contamination assessment of heavy metals in sediments the Manwan Reservoir, Lancang River. *Ecotoxicology and Environmental Safety*, *82*, 32-39.

Walker, S. L., Hedley, K., and Porter, E. (2002). Pulp and paper environmental effects monitoring in Canada: An overview. *Water Quality Research Journal of Canada. 37*:7–19.

Walker, T. R., and Grant, J. (2009). Quantifying erosion rates and stability of bottom sediments at mussel aquaculture sites in Prince Edward Island, Canada. *Journal of Marine Systems, 75*(1-2), 46-55.

Walker, T.R., MacAskill, D., and Weaver, P. (2013a). Environmental recovery in Sydney Harbour, Nova Scotia: evidence of natural and anthropogenic sediment capping. *Marine Pollution Bulletin* 74, 446–452.

Walker, T.R., MacAskill, D., Rushton, T., Thalheimer, A.H., and Weaver, P. (2013b). Monitoring effects of remediation on natural sediment recovery in Sydney Harbour, Nova Scotia. *Environment Monitoring Assessment. 185,* 8089–8107.

Walker, T.R., MacAskill, D., and Weaver, P. (2013c). Legacy contaminant bioaccumulation in rock crabs in Sydney Harbour during remediation of the Sydney Tar Ponds, Nova Scotia, Canada. *Marine Pollution Bulletin*. 77, 412–417.

Walker, T. R., Macaskill, D., and Weaver, P. (2013d). Blue mussels (*Mytilus edulis*) as bioindicators of stable water quality in Sydney Harbour during remediation of the Sydney Tar Ponds, Nova Scotia, Canada. *Water Quality Research Journal, 48(4),* 358-371.

Walker, T. R., and Grant, J. (2015). Metal (loid) s in sediment, lobster and mussel tissues near historical gold mine sites. *Marine Pollution Bulletin*, *101*(1), 404-408.

Walker, T. R., Willis, R., Gray, T., MacLean, B., Mcmillan, S., Leroy, M., and Smith, M. (2015). Ecological risk assessment of sediments in Sydney harbour, Nova Scotia, Canada. *Soil and Sediment Contamination: An International Journal, 24(5*), 471-493.

Walker, T. R., and MacAskill, D. (2014). Monitoring water quality in Sydney Harbour using blue mussels during remediation of the Sydney Tar Ponds, Nova Scotia, Canada. *Environmental Monitoring and Assessment*, *186*(3), 1623-1638.

Walker, T. R. (2016). Mercury concentrations in marine sediments near a former mercury cell chlor-alkali plant in eastern Canada. *Marine Pollution Bulletin, 107(1),* 398-401.

Willis, R. D., Hull, R. N., and Marshall, L. J. (2003). Considerations regarding the use of reference area and baseline information in ecological risk assessments. *Human and Ecological Risk Assessment, 9*(7), 1645-1653.

Whitney, P.R. (1975). Relationship of manganese-iron oxides and associated heavy metals to grain size in stream sediments. *Journal of Geochemical Exploration,4,* 251-263.

World Health Organization (WHO) (1997). International Agency for Research on Cancer. In: IARC Monographs on The Evaluation of Carcinogenic Risk to Humans, vol. 69. Lyon, France.
World Health Organization (2006). Retrieved from:
https://www.who.int/ipcs/assessment/tef_values.pdf

Yadav, S., and Chandra, R. (2018). Detection and assessment of the phytotoxicity of residual organic pollutants in sediment contaminated with pulp and paper mill effluent. *Environmental Monitoring and Assessment*, *190*(10), 581.

Zhang, H., and Davison, W. (1995). Performance characteristics of diffusion gradients in thin films for the in-situ measurement of trace metals in aqueous solution. Analytical chemistry, 67(19), 3391-3400.

Zhang, H., Davison, W., Knight, B., & McGrath, S. (1998). In situ measurements of solution concentrations and fluxes of trace metals in soils using DGT. Environmental science & technology, 32(5), 704-710.

Zhang, H., Walker, T. R., Davis, E., and Ma, G. (2019a). Spatiotemporal characterization of metals in small craft harbour sediments in Nova Scotia, Canada. *Marine Pollution Bulletin*. *140*. 493-502.

Zhang, H., Walker, T. R., Davis, E., & Ma, G. (2019b). Ecological risk assessment of metals in small craft harbour sediments in Nova Scotia, Canada. Marine pollution bulletin, 146, 466-475.

Zhao, S., Feng, C.H., Wang, D.X., Liu, Y.Z., and Shen, Z.Y. (2013). Salinity increases the mobility of Cd, Cu, Mn, and Pb in the sediments of Yangtze Estuary: relative role of sediments' properties and metal speciation. *Chemosphere. 91*, 977–984.

Zhou, Q., Zhang, J., Fu, J., Shi, J., and Jiang, G. (2008). Biomonitoring: an appealing tool for assessment of metal pollution in the aquatic ecosystem. *Analytica Chimica Acta 606*, 135–150.

Zhuang, W., and Gao, X. (2014). Assessment of heavy metal impact on sediment quality of the Xiaoqinghe estuary in the coastal Laizhou Bay, Bohai Sea: Inconsistency between two commonly used criteria. *Marine Pollution Bulletin*, *83*(1), 352-357.

APPENDIX -A

Image.1. Garmin GPS unit for recording waypoints of sampling stations.

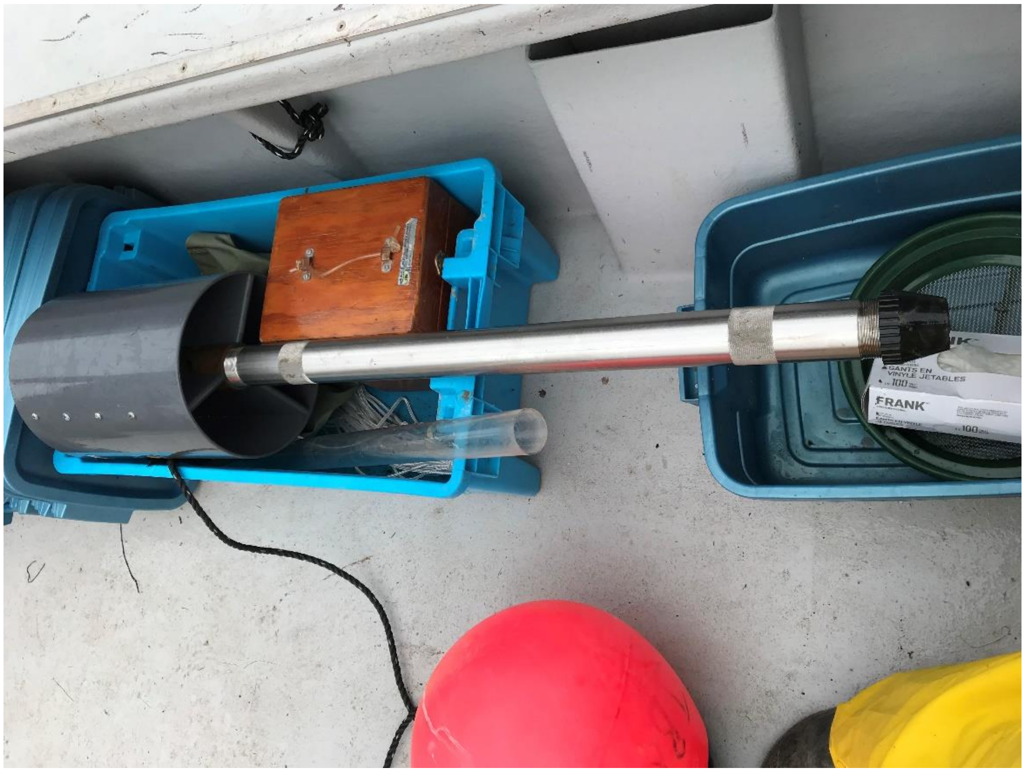

Image.2. Long gravity corer 2416 B45 (Wildco®) used for sediment sampling.

Image.3. Lobsters fishing boat used for sediment and biota sampling in July 2018.

Image.4. Small aluminium boat used for sediment sampling in May 2019.

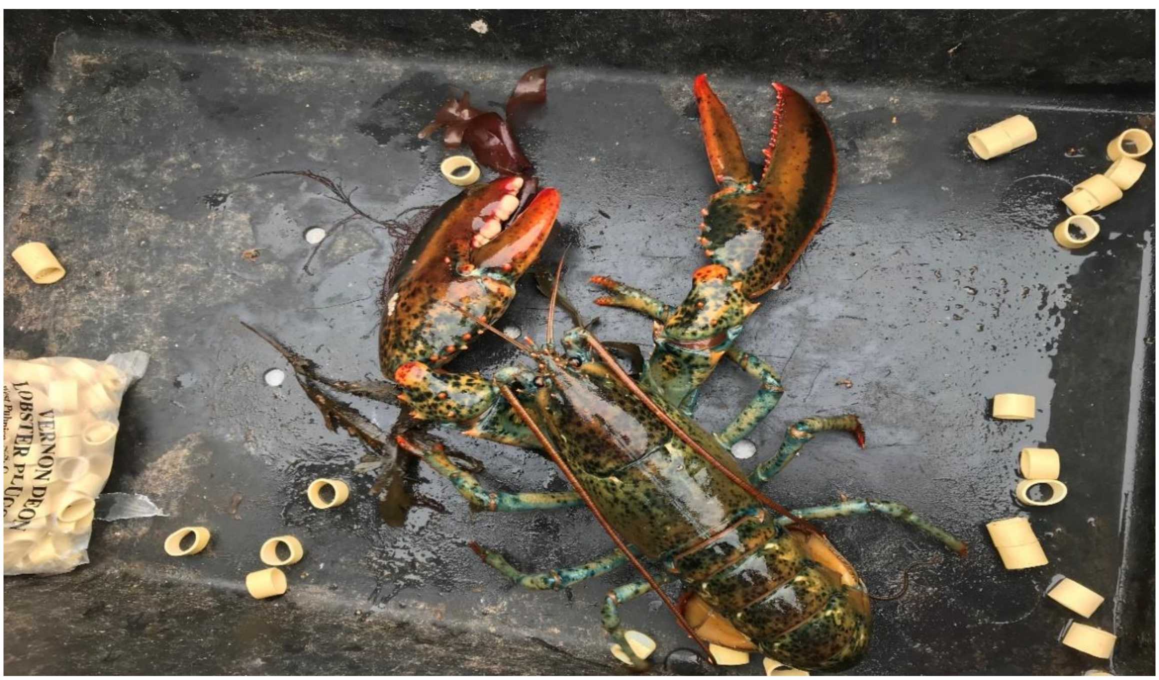

Image.5. Adult lobster (*Homarus americanus)*, of CL (180-125 mm) collected in July 2018.

Image.6. Rock crabs (*Cancer irroratus)* CL (103-113mm) collected in July 2018.

Image.7. Lobsters (*Homarus americanus)* and rock crabs' (*Cancer irroratus)* traps with DFO scientific tags.

Image.8. Blue mussels *(Mytilus edulis)* (56-60mm) shell length collected in July 2018.

VESSEL IDENTIFICATION

Activities carried out under the authority of this licence shall only be conducted using the following fishing vessel:

Vessel Name	VRN
Jason Rene	160576

PERIOD OF ACTIVITY

This licence is valid from July **9, 2018** to **July 13, 2018**.

NOTIFICATION REQUIREMENTS

Prior to commencing activities authorized under the authority of this licence, the licence holder or delegate must provide the Field Supervisor at the nearest Conservation and Protection office with the time and the location the activities are to be carried out and the details of the activities. Annex 'A' is a list of all Conservation and Protection offices in the Gulf Region.

REPORT REQUIREMENTS

A summary report on the project activities must be submitted to the Chief, Licensing, Fisheries and Oceans Canada, P.O. Box 5030, Moncton, NB, E1C 9B6 within 4 weeks of the expiry date of this licence.

ISSUED AT MONCTON, NB

Signature of Licence Holder

Licence not valid unless signed by DFO Authorized Person and Licence Holder.

Image.9. Department of Fisheries and Ocean (DFO) Scientific license.

Image 10. Diffusive gradient in thin films sediment probe disc.

Image. 11 DGT disc tied to cinder block and plastic cable ties.

Image. 12. Laboratory provided glass jars used for storing sediment samples.

APPENDIX B

AGAT Laboratories

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718

CLIENT NAME: NOVA SCOTIA LANDS INC PO BOX 430, STATION A
SYDNEY , NS B1P6H2
(902) 564-7933

ATTENTION TO: Tony Walker
PROJECT:
AGAT WORK ORDER: 18X361396
SOIL ANALYSIS REVIEWED BY: Laura Baker, Inorganics Data Reporter
ULTRA TRACE REVIEWED BY: Philippe Morneau, chimiste
DATE REPORTED: Jul 31, 2018
PAGES (INCLUDING COVER): 18
VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (902) 468-8718

NOT

Certificate of Analysis

AGAT WORK ORDER: 18X361396
PROJECT:

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:
ATTENTION TO: Tony Walker
SAMPLED BY:

Available Metals in Soil

DATE RECEIVED: 2018-07-12 **DATE REPORTED: 2018-07-31**

Parameter	Unit	G / S	RDL	N4	NE 4	NE 5	NE 6	NE 7	NE 8
			SAMPLE TYPE:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
			DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11
				9388054	9388059	9388060	9388061	9388062	9388063
Aluminum	mg/kg		10	7950	8350	8310	5880	7090	8930
Antimony	mg/kg		1	<1	<1	<1	<1	<1	<1
Arsenic	mg/kg		1	5	5	7	4	5	4
Barium	mg/kg		5	120	173	159	114	152	188
Beryllium	mg/kg		2	<2	<2	<2	<2	<2	<2
Boron	mg/kg		2	14	14	17	10	13	18
Cadmium	mg/kg		0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Chromium	mg/kg		2	17	18	18	13	15	19
Cobalt	mg/kg		1	9	9	9	6	8	9
Copper	mg/kg		2	11	10	8	6	7	9
Iron	mg/kg		50	17200	17100	17600	12300	15300	17600
Lead	mg/kg		0.5	11.4	12.4	9.8	8.1	9.2	11.2
Lithium	mg/kg		5	24	24	23	16	20	25
Manganese	mg/kg		2	311	269	292	199	376	300
Molybdenum	mg/kg		2	<2	<2	<2	<2	<2	<2
Nickel	mg/kg		2	20	21	20	13	17	21
Selenium	mg/kg		1	<1	<1	<1	<1	<1	<1
Silver	mg/kg		0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Strontium	mg/kg		5	20	17	20	13	16	21
Thallium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	mg/kg		2	3	3	3	3	3	3
Uranium	mg/kg		0.1	0.7	1.0	1.6	0.9	1.2	0.9
Vanadium	mg/kg		2	23	26	26	19	24	27
Zinc	mg/kg		5	59	59	47	44	46	58

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9388054-9388063 Results are based on the dry weight of the sample.

Certificate of Analysis

AGAT WORK ORDER: 18X361396
PROJECT:

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:
ATTENTION TO: Tony Walker
SAMPLED BY:

Grain Size Analysis - Coarse/Fine Classification

DATE RECEIVED: 2018-07-12 **DATE REPORTED: 2018-07-31**

Parameter	Unit	G / S	RDL	N4	NE 4	NE 5	NE 6	NE 7	NE 8
			SAMPLE TYPE:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
			DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11
				9388054	9388059	9388060	9388061	9388062	9388063
Particles >75um	%		1	42	34	51	71	62	46
Classification	Coarse/Fine			Fine	Fine	Coarse	Coarse	Coarse	Fine

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 18X361396
PROJECT:

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Inorganics (Soil)

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-07-31

						SAMPLE DESCRIPTION:	N4	NE 4	NE 5	NE 6	NE 7
						SAMPLE TYPE:	Sediment	Sediment	Sediment	Sediment	Sediment
						DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Parameter	Unit	G / S: A	G / S: B	G / S: C	G / S: D	RDL	8388054	8388059	8388060	8388061	8388062
Total Organic Carbon	%					0.3	0.9	0.8	1.5	0.4	0.6
Moisture Content	%					0.1	40.7	28.7	45.3	21.8	26.0

						SAMPLE DESCRIPTION:	NE 8
						SAMPLE TYPE:	Sediment
						DATE SAMPLED:	2018-07-11
Parameter	Unit	G / S: A	G / S: B	G / S: C	G / S: D	RDL	8388063
Total Organic Carbon	%					0.3	0.6
Moisture Content	%					0.1	26.9

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: A Refers to Basses-Terres du St-Laurent, B Refers to QC PTC 2016 B, C Refers to QC PTC 2016 C, D Refers to QC RESC (Annexe 1)
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 18X361396
PROJECT:

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Dartmouth, Nova Scotia
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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Mercury Analysis in Soil

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-07-31

			SAMPLE DESCRIPTION:	N4	NE 4	NE 5	NE 6	NE 7	NE 8
			SAMPLE TYPE:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
			DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Parameter	Unit	G / S	RDL	8388054	8388059	8388060	8388061	8388062	8388063
Mercury	mg/kg		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
8388054-8388063 Results are based on the dry weight of the soil.

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CLIENT NAME: NOVA SCOTIA LANDS INC **ATTENTION TO: Tony Walker**
SAMPLING SITE: **SAMPLED BY:**

Dioxins and Furans (Sediment, WHO 1998, Fish)

DATE RECEIVED: 2018-07-12 **DATE REPORTED: 2018-07-31**

Parameter	Unit	G / S	RDL	N4	RDL	NE 4	RDL	NE 5	RDL	NE 6
			SAMPLE TYPE:	Sediment		Sediment		Sediment		Sediment
			DATE SAMPLED:	2018-07-11		2018-07-11		2018-07-11		2018-07-11
				9388054		9388059		9388060		9388061
1,2,3,6,7,8-Hexa CDD (TEF 0.01)	TEQ			0.00674		0		0		0
1,2,3,7,8,9-Hexa CDD (TEF 0.01)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.001)	TEQ			0.00221		0		0.00282		0.00131
Octa CDD (TEF 0.0001)	TEQ			0.00250		0.00372		0.00540		0.00282
2,3,7,8-Tetra CDF (TEF 0.5)	TEQ			0		0		0		0
1,2,3,7,8-Penta CDF (TEF 0.5)	TEQ			0		0		0		0
2,3,4,7,8-Penta CDF (TEF 0.5)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0.126		0
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0.00718		0		0.0172		0.00672
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
Octa CDF (TEF 0.0001)	TEQ			0.000221		0		0.000324		0.000371
Total PCDDs & PCDFs (TEQ)	TEQ			0.0189		0.00372		0.152		0.0112

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CLIENT NAME: NOVA SCOTIA LANDS INC

ATTENTION TO: Tony Walker

SAMPLING SITE:

SAMPLED BY:

Dioxins and Furans (Sediment, WHO 1998, Fish)

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-07-31

		SAMPLE DESCRIPTION:	N4	NE 4	NE 5	NE 6
		SAMPLE TYPE:	Sediment	Sediment	Sediment	Sediment
		DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Surrogate	Unit	Acceptable Limits	9398054	9398059	9398060	9398061
13C-2378-TCDF	%	30-140	64	64	68	66
13C-12378-PeCDF	%	30-140	58	57	47	62
13C-23478-PeCDF	%	30-140	59	62	47	65
13C-123478-HxCDF	%	30-140	57	63	49	63
13C-123678-HxCDF	%	30-140	64	65	55	65
13C-234678-HxCDF	%	30-140	69	73	53	69
13C-123789-HxCDF	%	30-140	68	68	73	69
13C-1234678-HpCDF	%	30-140	49	49	48	50
13C-1234789-HpCDF	%	30-140	48	46	46	50
13C-2378-TCDD	%	30-140	74	74	98	77
13C-12378-PeCDD	%	30-140	64	64	58	67
13C-123478-HxCDD	%	30-140	67	74	44	69
13C-123678-HxCDD	%	30-140	68	70	67	71
13C-1234678-HpCDD	%	30-140	50	52	52	51
13C-OCDD	%	30-140	36	38	31	37

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Certificate of Analysis

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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Dioxins and Furans (Sediment, WHO 1998, Fish)

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-07-31

			SAMPLE DESCRIPTION:	NE 7		NE 8
			SAMPLE TYPE:	Sediment		Sediment
			DATE SAMPLED:	2018-07-11		2018-07-11
Parameter	Unit	G / S	RDL	9388062	RDL	9388063
2,3,7,8-Tetra CDD	ng/kg		0.2	<0.2	0.1	<0.1
1,2,3,7,8-Penta CDD	ng/kg		0.6	<0.6	0.2	<0.2
1,2,3,4,7,8-Hexa CDD	ng/kg		0.7	<0.7	0.7	<0.7
1,2,3,6,7,8-Hexa CDD	ng/kg		0.7	<0.7	0.7	<0.7
1,2,3,7,8,9-Hexa CDD	ng/kg		0.7	<0.7	0.7	<0.7
1,2,3,4,6,7,8-Hepta CDD	ng/kg		0.6	0.7	0.6	<0.6
Octa CDD	ng/kg		2	14	1	14
2,3,7,8-Tetra CDF	ng/kg		0.3	<0.3	0.2	0.4
1,2,3,7,8-Penta CDF	ng/kg		0.5	<0.5	0.4	<0.4
2,3,4,7,8-Penta CDF	ng/kg		0.4	0.5	0.4	<0.4
1,2,3,4,7,8-Hexa CDF	ng/kg		0.6	0.7	0.4	0.6
1,2,3,6,7,8-Hexa CDF	ng/kg		0.6	<0.6	0.2	<0.2
2,3,4,6,7,8-Hexa CDF	ng/kg		0.7	<0.7	0.5	<0.5
1,2,3,7,8,9-Hexa CDF	ng/kg		0.9	<0.9	0.6	<0.6
1,2,3,4,6,7,8-Hepta CDF	ng/kg		1	1	0.5	0.5
1,2,3,4,7,8,9-Hepta CDF	ng/kg		2	<2	0.9	<0.9
Octa CDF	ng/kg		1	2	0.7	1.4
Total Tetrachlorodibenzodioxins	ng/kg		0.2	0.8	0.1	0.2
Total Pentachlorodibenzodioxins	ng/kg		0.6	1.4	0.2	0.6
Total Hexachlorodibenzodioxins	ng/kg		0.7	3.2	0.7	1.8
Total Heptachlorodibenzodioxins	ng/kg		0.6	4.5	0.6	1.6
Total PCDDs	ng/kg		2	24	1	18
Total Tetrachlorodibenzofurans	ng/kg		0.3	2.8	0.2	1.8
Total Pentachlorodibenzofurans	ng/kg		0.5	3.2	0.4	0.9
Total Hexachlorodibenzofurans	ng/kg		0.9	3.9	0.6	1.1
Total Heptachlorodibenzofurans	ng/kg		2	4	0.9	1.0
Total PCDFs	ng/kg		2	15	0.9	6.3
2,3,7,8-Tetra CDD (TEF 1.0)	TEQ			0		0
1,2,3,7,8-Penta CDD (TEF 1.0)	TEQ			0		0
1,2,3,4,7,8-Hexa CDD (TEF 0.5)	TEQ			0		0

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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Dioxins and Furans (Sediment, WHO 1998, Fish)

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-07-31

		SAMPLE DESCRIPTION:	NE 7	NE 8
		SAMPLE TYPE:	Sediment	Sediment
		DATE SAMPLED:	2018-07-11	2018-07-11
Surrogate	Unit	Acceptable Limits	9398062	9398063
13C-2378-TCDF	%	30-140	63	67
13C-12378-PeCDF	%	30-140	61	60
13C-23478-PeCDF	%	30-140	69	74
13C-123478-HxCDF	%	30-140	65	70
13C-123678-HxCDF	%	30-140	65	70
13C-234678-HxCDF	%	30-140	68	65
13C-123789-HxCDF	%	30-140	71	67
13C-1234678-HpCDF	%	30-140	55	61
13C-1234789-HpCDF	%	30-140	53	55
13C-2378-TCDD	%	30-140	79	80
13C-12378-PeCDD	%	30-140	72	72
13C-123478-HxCDD	%	30-140	70	67
13C-123678-HxCDD	%	30-140	76	83
13C-1234678-HpCDD	%	30-140	58	59
13C-OCDD	%	30-140	38	37

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9398054-9398063 The results were corrected based on the surrogate percent recoveries.

Certificate of Analysis

AGAT Laboratories

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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Dioxins and Furans (Sediment, WHO 1998, Fish)

DATE RECEIVED: 2018-07-12 **DATE REPORTED: 2018-07-31**

			SAMPLE DESCRIPTION:	NE 7		NE 8
			SAMPLE TYPE:	Sediment		Sediment
			DATE SAMPLED:	2018-07-11		2018-07-11
Parameter	Unit	G / S	RDL	9388082	RDL	9388083
1,2,3,6,7,8-Hexa CDD (TEF 0.01)	TEQ			0		0
1,2,3,7,8,9-Hexa CDD (TEF 0.01)	TEQ			0		0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.001)	TEQ			0.000692		0
Octa CDD (TEF 0.0001)	TEQ			0.00137		0.00142
2,3,7,8-Tetra CDF (TEF 0.5)	TEQ			0		0.0209
1,2,3,7,8-Penta CDF (TEF 0.5)	TEQ			0		0
2,3,4,7,8-Penta CDF (TEF 0.5)	TEQ			0.255		0
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0.0663		0.0588
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0		0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0.0118		0.00527
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0		0
Octa CDF (TEF 0.0001)	TEQ			0.000198		0.000141
Total PCDDs & PCDFs (TEQ)	TEQ			0.335		0.0866

AGAT Laboratories

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Quality Assurance

CLIENT NAME: NOVA SCOTIA LANDS INC
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 18X361396
ATTENTION TO: Tony Walker
SAMPLED BY:

Soil Analysis

RPT Date: Jul 31, 2018			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Available Metals in Soil															
Aluminum	9396063	9396063	9780	9830	0.5%	< 10	113%	80%	120%	111%	80%	120%	125%	70%	130%
Antimony	9396063	9396063	<1	<1	NA	< 1	97%	80%	120%	106%	80%	120%	NA	70%	130%
Arsenic	9396063	9396063	4	5	NA	< 1	97%	80%	120%	95%	80%	120%	96%	70%	130%
Barium	9396063	9396063	188	183	2.3%	< 5	96%	80%	120%	98%	80%	120%	96%	70%	130%
Beryllium	9396063	9396063	<2	<2	NA	< 2	106%	80%	120%	107%	80%	120%	107%	70%	130%
Boron	9396063	9396063	18	16	9.2%	< 2	106%	80%	120%	105%	80%	120%	109%	70%	130%
Cadmium	9396063	9396063	<0.3	<0.3	NA	< 0.3	95%	80%	120%	98%	80%	120%	101%	70%	130%
Chromium	9396063	9396063	19	19	0.0%	< 2	100%	80%	120%	105%	80%	120%	113%	70%	130%
Cobalt	9396063	9396063	9	9	1.9%	< 1	100%	80%	120%	101%	80%	120%	107%	70%	130%
Copper	9396063	9396063	9	9	NA	< 2	109%	80%	120%	105%	80%	120%	105%	70%	130%
Iron	9396063	9396063	18300	18400	0.2%	< 50	105%	80%	120%	114%	80%	120%	101%	70%	130%
Lead	9396063	9396063	11.2	11.2	0.2%	< 0.5	102%	80%	120%	103%	80%	120%	104%	70%	130%
Lithium	9396063	9396063	25	25	0.1%	< 5	108%	70%	130%	107%	70%	130%	110%	70%	130%
Manganese	9396063	9396063	328	346	5.3%	< 2	113%	80%	120%	108%	80%	120%	101%	70%	130%
Molybdenum	9396063	9396063	<2	<2	NA	< 2	96%	80%	120%	102%	80%	120%	99%	70%	130%
Nickel	9396063	9396063	21	21	0.2%	< 2	101%	80%	120%	107%	80%	120%	109%	70%	130%
Selenium	9396063	9396063	<1	<1	NA	< 1	97%	80%	120%	93%	80%	120%	89%	70%	130%
Silver	9396063	9396063	<0.5	<0.5	NA	< 0.5	86%	80%	120%	100%	80%	120%	90%	70%	130%
Strontium	9396063	9396063	21	21	NA	< 5	102%	80%	120%	104%	80%	120%	113%	70%	130%
Thallium	9396063	9396063	<0.1	<0.1	NA	< 0.1	100%	80%	120%	101%	80%	120%	NA	70%	130%
Tin	9396063	9396063	3	3	NA	< 2	97%	80%	120%	99%	80%	120%	102%	70%	130%
Uranium	9396063	9396063	0.9	1.0	5.6%	< 0.1	97%	80%	120%	98%	80%	120%	108%	70%	130%
Vanadium	9396063	9396063	27	27	0.4%	< 2	96%	80%	120%	98%	80%	120%	111%	70%	130%
Zinc	9396063	9396063	58	57	1.3%	< 5	99%	80%	120%	101%	80%	120%	103%	70%	130%
Mercury Analysis in Soil															
Mercury	1	9341958	1500	1490	0.7%	< 0.05	95%	70%	130%	NA	70%	130%	100%	70%	130%
Inorganics (Soil)															
Total Organic Carbon	9394454		11.2	11.0	1.8%	< 0.3	NA	80%	120%	NA	80%	120%	NA	80%	120%

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Quality Assurance

CLIENT NAME: NOVA SCOTIA LANDS INC
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 18X361396
ATTENTION TO: Tony Walker
SAMPLED BY:

Ultra Trace Analysis

RPT Date: Jul 31, 2018			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Dioxins and Furans (Sediment, WHO 1998, Fish)															
2,3,7,8-Tetra CDD	1	NA	< 0.2	< 0.2	NA	< 0.1	98%	40%	130%	NA	40%	130%	94%	40%	130%
1,2,3,7,8-Penta CDD	1	NA	< 0.4	< 0.5	NA	< 0.2	106%	40%	130%	NA	40%	130%	100%	40%	130%
1,2,3,4,7,8-Hexa CDD	1	NA	< 0.7	< 0.7	NA	< 0.7	104%	40%	130%	NA	40%	130%	105%	40%	130%
1,2,3,6,7,8-Hexa CDD	1	NA	< 0.7	< 0.7	NA	< 0.7	110%	40%	130%	NA	40%	130%	105%	40%	130%
1,2,3,7,8,9-Hexa CDD	1	NA	< 0.7	0.8	NA	< 0.7	103%	40%	130%	NA	40%	130%	107%	40%	130%
1,2,3,4,6,7,8-Hepta CDD	1	NA	1.3	1.4	NA	< 0.2	101%	40%	130%	NA	40%	130%	105%	40%	130%
Octa CDD	1	NA	9	10	10.5%	< 0.5	101%	40%	130%	NA	40%	130%	102%	40%	130%
2,3,7,8-Tetra CDF	1	NA	< 0.3	< 0.5	NA	< 0.1	109%	40%	130%	NA	40%	130%	103%	40%	130%
1,2,3,7,8-Penta CDF	1	NA	0.7	< 2	NA	< 0.4	113%	40%	130%	NA	40%	130%	110%	40%	130%
2,3,4,7,8-Penta CDF	1	NA	< 0.4	< 0.9	NA	< 0.4	117%	40%	130%	NA	40%	130%	113%	40%	130%
1,2,3,4,7,8-Hexa CDF	1	NA	0.4	< 1	NA	< 0.4	111%	40%	130%	NA	40%	130%	111%	40%	130%
1,2,3,6,7,8-Hexa CDF	1	NA	< 0.4	< 0.9	NA	< 0.1	112%	40%	130%	NA	40%	130%	111%	40%	130%
2,3,4,6,7,8-Hexa CDF	1	NA	< 0.8	< 1	NA	< 0.5	111%	40%	130%	NA	40%	130%	111%	40%	130%
1,2,3,7,8,9-Hexa CDF	1	NA	< 0.8	< 1	NA	< 0.8	103%	40%	130%	NA	40%	130%	105%	40%	130%
1,2,3,4,6,7,8-Hepta CDF	1	NA	0.5	< 1	NA	< 0.5	109%	40%	130%	NA	40%	130%	112%	40%	130%
1,2,3,4,7,8,9-Hepta CDF	1	NA	< 0.9	< 2	NA	< 0.9	105%	40%	130%	NA	40%	130%	104%	40%	130%
Octa CDF	1	NA	< 2	< 2	NA	< 0.7	100%	40%	130%	NA	40%	130%	107%	40%	130%

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Method Summary

CLIENT NAME: NOVA SCOTIA LANDS INC
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 18X361396
ATTENTION TO: Tony Walker
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Aluminum	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Antimony	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Arsenic	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Barium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Beryllium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Boron	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Cadmium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Chromium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Cobalt	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Copper	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Iron	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Lead	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP-MS
Lithium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP-MS
Manganese	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Molybdenum	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Nickel	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Selenium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Silver	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Strontium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Thallium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Tin	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Uranium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Vanadium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Zinc	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Particles >75um	INOR-121-6031, INOR-121-6034	ASTM D-422-63	Sieve
Classification	INOR-121-6031, INOR-121-6031	Atlantic RBCA	Sieve
Total Organic Carbon	INOR-101-6057F	MA. 405-C 1.1	TITRAGE
Moisture Content	LAB-111-4040F	MA.100-ST 1.1	BALANCE

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Method Summary

CLIENT NAME: NOVA SCOTIA LANDS INC

PROJECT:

SAMPLING SITE:

AGAT WORK ORDER: 18X361398

ATTENTION TO: Tony Walker

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Ultra Trace Analysis			
2,3,7,8-Tetra CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8-Penta CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8-Hexa CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,6,7,8-Hexa CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8,9-Hexa CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,4,6,7,8-Hepta CDD	HR-151-5400	EPA 1613	HRMS
Octa CDD	HR-151-5400	EPA 1613	HRMS
2,3,7,8-Tetra CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8-Penta CDF	HR-151-5400	EPA 1613	HRMS
2,3,4,7,8-Penta CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8-Hexa CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,6,7,8-Hexa CDF	HR-151-5400	EPA 1613	HRMS
2,3,4,6,7,8-Hexa CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8,9-Hexa CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,4,6,7,8-Hepta CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8,9-Hepta CDF	HR-151-5400	EPA 1613	HRMS
Octa CDF	HR-151-5400	EPA 1613	HRMS
Total Tetrachlorodibenzodioxins	HR-151-5400	EPA 1613	HRMS
Total Pentachlorodibenzodioxins	HR-151-5400	EPA 1613	HRMS
Total Hexachlorodibenzodioxins	HR-151-5400	EPA 1613	HRMS
Total Heptachlorodibenzodioxins	HR-151-5400	EPA 1613	HRMS
Total PCDDs	HR-151-5400	EPA 1613	HRMS
Total Tetrachlorodibenzofurans	HR-151-5400	EPA 1613	HRMS
Total Pentachlorodibenzofurans	HR-151-5400	EPA 1613	HRMS
Total Hexachlorodibenzofurans	HR-151-5400	EPA 1613	HRMS
Total Heptachlorodibenzofurans	HR-151-5400	EPA 1613	HRMS
Total PCDFs	HR-151-5400	EPA 1613	HRMS
2,3,7,8-Tetra CDD (TEF 1.0)	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8-Penta CDD (TEF 1.0)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8-Hexa CDD (TEF 0.5)	HR-151-5400	EPA 1613	HRMS
1,2,3,6,7,8-Hexa CDD (TEF 0.01)	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8,9-Hexa CDD (TEF 0.01)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,6,7,8-Hepta CDD (TEF 0.001)	HR-151-5400	EPA 1613	HRMS
Octa CDD (TEF 0.0001)	HR-151-5400	EPA 1613	HRMS
2,3,7,8-Tetra CDF (TEF 0.5)	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8-Penta CDF (TEF 0.5)	HR-151-5400	EPA 1613	HRMS
2,3,4,7,8-Penta CDF (TEF 0.5)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	HR_151-5400	EPA 1613	HRMS
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	HR-151-5400	EPA 1613	HRMS
Octa CDF (TEF 0.0001)	HR-151-5400	EPA 1613	HRMS
Total PCDDs & PCDFs (TEQ)	HR-151-5400	EPA 1613	HRMS
13C-2378-TCDF	HR-151-5400	EPA 1613	HRMS
13C-12378-PeCDF	HR-151-5400	EPA 1613	HRMS
13C-23478-PeCDF	HR-151-5400	EPA 1613	HRMS
13C-123478-HxCDF	HR-151-5400	EPA 1613	HRMS

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Method Summary

CLIENT NAME: NOVA SCOTIA LANDS INC — AGAT WORK ORDER: 18X361396

PROJECT: — ATTENTION TO: Tony Walker

SAMPLING SITE: — SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
13C-123678-HxCDF	HR-151-5400	EPA 1613	HRMS
13C-234678-HxCDF	HR-151-5400	EPA 1613	HRMS
13C-123789-HxCDF	HR-151-5400	EPA 1613	HRMS
13C-1234678-HpCDF	HR-151-5400	EPA 1613	HRMS
13C-1234789-HpCDF	HR-151-5400	EPA 1613	HRMS
13C-2378-TCDD	HR-151-5400	EPA 1613	HRMS
13C-12378-PeCDD	HR-151-5400	EPA 1613	HRMS
13C-123478-HxCDD	HR-151-5400	EPA 1613	HRMS
13C-123678-HxCDD	HR-151-5400	EPA 1613	HRMS
13C-1234678-HpCDD	HR-151-5400	EPA 1613	HRMS
13C-OCDD	HR-151-5400	EPA 1613	HRMS

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19X470398

PROJECT:

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CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES

ATTENTION TO: Heather Daurie

SAMPLING SITE:

SAMPLED BY:

Mercury in Soil

DATE RECEIVED: 2019-05-23

DATE REPORTED: 2019-06-18

Parameter	Unit	G / S	RDL	N1	N2	N3	NE1	NE2	NE3
SAMPLE TYPE:				Soil	Soil	Soil	Soil	Soil	Soil
DATE SAMPLED:				2019-05-21	2019-05-21	2019-05-21	2019-05-21	2019-05-21	2019-05-21
				215578	215581	215582	215583	215584	215585
Mercury	mg/kg		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

215578-215585 Results are based on the dry weight of the soil.

Analysis performed at AGAT Halifax (unless marked by *)

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19X470398

PROJECT:

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CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES

ATTENTION TO: Heather Daurie

SAMPLING SITE:

SAMPLED BY:

Grain Size Analysis - Coarse/Fine Classification

DATE RECEIVED: 2019-05-23

DATE REPORTED: 2019-06-18

Parameter	Unit	G / S	RDL	N1	N2	N3	NE1	NE2	NE3
SAMPLE TYPE:				Soil	Soil	Soil	Soil	Soil	Soil
DATE SAMPLED:				2019-05-21	2019-05-21	2019-05-21	2019-05-21	2019-05-21	2019-05-21
				215578	215581	215582	215583	215584	215585
Particles >75um	%		1	99	100	99	100	96	99
Classification	Coarse/Fine			Coarse	Coarse	Coarse	Coarse	Coarse	Coarse

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Analysis performed at AGAT Halifax (unless marked by *)

AGAT Laboratories

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AGAT WORK ORDER: 19X470398

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CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES

ATTENTION TO: Heather Daurie

SAMPLING SITE:

SAMPLED BY:

Available Metals in Soil

DATE RECEIVED: 2019-05-23

DATE REPORTED: 2019-06-18

			SAMPLE DESCRIPTION:	N1	N2	N3	NE1	NE2	NE3
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2019-05-21	2019-05-21	2019-05-21	2019-05-21	2019-05-21	2019-05-21
Parameter	Unit	G / S	RDL	215578	215581	215582	215583	215584	215585
Aluminum	mg/kg		10	4150	2360	3570	2790	3480	2940
Antimony	mg/kg		1	<1	<1	<1	<1	<1	<1
Arsenic	mg/kg		1	5	3	5	5	6	5
Barium	mg/kg		5	90	21	36	59	42	42
Beryllium	mg/kg		2	<2	<2	<2	<2	<2	<2
Boron	mg/kg		2	4	4	4	2	5	4
Cadmium	mg/kg		0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Chromium	mg/kg		2	6	3	5	5	6	5
Cobalt	mg/kg		1	4	2	3	3	4	3
Copper	mg/kg		2	4	<2	<2	3	2	2
Iron	mg/kg		50	6740	4060	6320	3870	5770	5450
Lead	mg/kg		0.5	3.2	1.9	3.0	3.1	3.0	2.7
Lithium	mg/kg		5	12	7	11	10	12	9
Manganese	mg/kg		2	706	283	455	495	524	585
Molybdenum	mg/kg		2	<2	<2	<2	<2	<2	<2
Nickel	mg/kg		2	8	4	6	6	7	6
Selenium	mg/kg		1	<1	<1	<1	<1	<1	<1
Silver	mg/kg		0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Strontium	mg/kg		5	9	6	6	5	8	8
Thallium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	mg/kg		2	4	4	4	3	4	4
Uranium	mg/kg		0.1	0.2	0.1	0.2	0.2	0.2	0.2
Vanadium	mg/kg		2	11	7	11	9	11	11
Zinc	mg/kg		5	30	18	25	21	30	25

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

215578-215585 Results are based on the dry weight of the sample.

Analysis performed at AGAT Halifax (unless marked by *)

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Certificate of Analysis

AGAT WORK ORDER: 19X470398
PROJECT:

CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES
SAMPLING SITE:

ATTENTION TO: Heather Daurie
SAMPLED BY:

Grain Size Analysis - Coarse/Fine Classification

DATE RECEIVED: 2019-05-23 | DATE REPORTED: 2019-06-18

			SAMPLE DESCRIPTION:	N1	N2	N3	NE1	NE2	NE3
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2019-05-21	2019-05-21	2019-05-21	2019-05-21	2019-05-21	2019-05-21
Parameter	Unit	G / S	RDL	215578	215581	215582	215583	215584	215586
Particles >75um	%		1	99	100	99	100	96	99
Classification	Coarse/Fine			Coarse	Coarse	Coarse	Coarse	Coarse	Coarse

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Halifax (unless marked by *)

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Certificate of Analysis

AGAT WORK ORDER: 19X470398
PROJECT:

CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES
SAMPLING SITE:

ATTENTION TO: Heather Daurie
SAMPLED BY:

Mercury in Soil

DATE RECEIVED: 2019-05-23 | DATE REPORTED: 2019-06-18

			SAMPLE DESCRIPTION:	N1	N2	N3	NE1	NE2	NE3
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2019-05-21	2019-05-21	2019-05-21	2019-05-21	2019-05-21	2019-05-21
Parameter	Unit	G / S	RDL	215578	215581	215582	215583	215584	215586
Mercury	mg/kg		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
215578-215586 Results are based on the dry weight of the soil.
Analysis performed at AGAT Halifax (unless marked by *)

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Certificate of Analysis

AGAT WORK ORDER: 19X470398
PROJECT:

CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES
SAMPLING SITE:

ATTENTION TO: Heather Daurie
SAMPLED BY:

Methylmercury in Soil

DATE RECEIVED: 2019-05-23 | DATE REPORTED: 2019-06-18

			SAMPLE DESCRIPTION:	N1	N2	N3	NE1	NE2	NE3
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2019-05-21	2019-05-21	2019-05-21	2019-05-21	2019-05-21	2019-05-21
Parameter	Unit	G / S	RDL	215578	215581	215582	215583	215584	215586
Methyl Mercury	ng/g		0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Halifax (unless marked by *)

Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 19X470398
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CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES
SAMPLING SITE:
ATTENTION TO: Heather Daurie
SAMPLED BY:

Dioxins and Furans (Soil, WHO 2005)

DATE RECEIVED: 2019-05-23 **DATE REPORTED: 2019-06-18**

			SAMPLE DESCRIPTION:	N1		N2		N3		NE1
			SAMPLE TYPE:	Soil		Soil		Soil		Soil
			DATE SAMPLED:	2019-05-21		2019-05-21		2019-05-21		2019-05-21
Parameter	Unit	G / S	RDL	215578	RDL	215581	RDL	215582	RDL	215583
2,3,7,8-Tetra CDD	ng/kg		0.1	<0.1	0.1	<0.1	0.2	<0.2	0.1	<0.1
1,2,3,7,8-Penta CDD	ng/kg		0.1	<0.1	0.2	<0.2	0.2	<0.2	0.1	<0.1
1,2,3,4,7,8-Hexa CDD	ng/kg		0.3	<0.3	0.2	<0.2	0.9	<0.9	0.6	<0.6
1,2,3,6,7,8-Hexa CDD	ng/kg		0.2	<0.2	0.2	<0.2	0.9	<0.9	0.5	<0.5
1,2,3,7,8,9-Hexa CDD	ng/kg		0.3	<0.3	0.3	<0.3	1	<1	0.6	<0.6
1,2,3,4,6,7,8-Hepta CDD	ng/kg		0.6	<0.6	0.2	<0.2	0.4	<0.4	1	<1
Octa CDD	ng/kg		4	14	2	3	2	<2	4	18
2,3,7,8-Tetra CDF	ng/kg		0.2	<0.2	0.1	<0.1	0.2	<0.2	0.1	<0.1
1,2,3,7,8-Penta CDF	ng/kg		0.2	<0.2	0.1	<0.1	0.1	<0.1	0.2	<0.2
2,3,4,7,8-Penta CDF	ng/kg		0.2	<0.2	0.1	<0.1	0.1	<0.1	0.1	<0.1
1,2,3,4,7,8-Hexa CDF	ng/kg		0.3	<0.3	0.3	<0.3	0.2	<0.2	0.2	<0.2
1,2,3,6,7,8-Hexa CDF	ng/kg		0.2	<0.2	0.3	<0.3	0.1	<0.1	0.2	<0.2
2,3,4,6,7,8-Hexa CDF	ng/kg		0.2	<0.2	0.3	<0.3	0.1	<0.1	0.2	<0.2
1,2,3,7,8,9-Hexa CDF	ng/kg		0.4	<0.4	0.5	<0.5	0.2	<0.2	0.3	<0.3
1,2,3,4,6,7,8-Hepta CDF	ng/kg		0.5	<0.5	0.2	<0.2	0.9	<0.9	0.8	<0.8
1,2,3,4,7,8,9-Hepta CDF	ng/kg		1	<1	0.4	<0.4	2	<2	2	<2
Octa CDF	ng/kg		2	<2	2	<2	3	<3	3	<3
Total Tetrachlorodibenzodioxins	ng/kg		0.1	0.4	0.1	<0.1	0.2	1.2	0.1	<0.1
Total Pentachlorodibenzodioxins	ng/kg		0.1	0.4	0.2	0.2	0.2	<0.2	0.1	0.6
Total Hexachlorodibenzodioxins	ng/kg		0.3	<0.3	0.2	<0.2	0.9	<0.9	0.6	<0.6
Total Heptachlorodibenzodioxins	ng/kg		0.6	<0.6	0.2	<0.2	0.4	<0.4	1	<1
Total PCDDs	ng/kg		4	14	2	<2	2	<2	4	18
Total Tetrachlorodibenzofurans	ng/kg		0.2	<0.2	0.1	<0.1	0.2	<0.2	0.1	<0.1
Total Pentachlorodibenzofurans	ng/kg		0.2	<0.2	0.1	<0.1	0.1	<0.1	0.2	0.2
Total Hexachlorodibenzofurans	ng/kg		0.4	0.6	0.5	<0.5	0.2	<0.2	0.3	<0.3
Total Heptachlorodibenzofurans	ng/kg		1	<1	0.4	<0.4	2	<2	2	<2
Total PCDFs	ng/kg		2	<2	2	<2	3	<3	3	<3
2,3,7,8-Tetra CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,7,8-Penta CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0

Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 19X470398
PROJECT:

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CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES
SAMPLING SITE:
ATTENTION TO: Heather Daurie
SAMPLED BY:

Dioxins and Furans (Soil, WHO 2005)

DATE RECEIVED: 2019-05-23 **DATE REPORTED: 2019-06-18**

			SAMPLE DESCRIPTION:	N1		N2		N3		NE1
			SAMPLE TYPE:	Soil		Soil		Soil		Soil
			DATE SAMPLED:	2019-05-21		2019-05-21		2019-05-21		2019-05-21
Parameter	Unit	G / S	RDL	215578	RDL	215581	RDL	215582	RDL	215583
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	TEQ			0		0		0		0
Octa CDD (TEF 0.0003)	TEQ			0.00408		0.00103		0		0.00537
2,3,7,8-Tetra CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8-Penta CDF (TEF 0.03)	TEQ			0		0		0		0
2,3,4,7,8-Penta CDF (TEF 0.3)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
Octa CDF (TEF 0.0003)	TEQ			0		0		0		0
Total PCDDs and PCDFs (TEQ)	ng/kg TEQ			0.00408		0.00103		0		0.00537

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AGAT WORK ORDER: 19X470398
PROJECT:

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CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES
ATTENTION TO: Heather Daurie
SAMPLING SITE:
SAMPLED BY:

Dioxins and Furans (Soil, WHO 2005)

DATE RECEIVED: 2019-05-23
DATE REPORTED: 2019-06-18

		SAMPLE DESCRIPTION:	N1	N2	N3	NE1
		SAMPLE TYPE:	Soil	Soil	Soil	Soil
		DATE SAMPLED:	2019-05-21	2019-05-21	2019-05-21	2019-05-21
Surrogate	Unit	Acceptable Limits	215578	215581	215582	215583
13C-2378-TCDF	%	30-140	62	63	45	58
13C-12378-PeCDF	%	30-140	58	59	38	47
13C-23478-PeCDF	%	30-140	78	81	46	68
13C-123478-HxCDF	%	30-140	81	85	63	61
13C-123678-HxCDF	%	30-140	78	73	66	61
13C-234678-HxCDF	%	30-140	94	85	85	59
13C-123789-HxCDF	%	30-140	95	84	79	66
13C-1234678-HpCDF	%	30-140	63	61	48	44
13C-1234789-HpCDF	%	30-140	54	53	35	43
13C-2378-TCDD	%	30-140	68	74	49	70
13C-12378-PeCDD	%	30-140	77	78	51	70
13C-123478-HxCDD	%	30-140	88	91	84	76
13C-123678-HxCDD	%	30-140	92	88	82	73
13C-1234678-HpCDD	%	30-140	58	59	43	45
13C-OCDD	%	30-140	33	30	28	21

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Dioxins and Furans (Soil, WHO 2005)

DATE RECEIVED: 2019-05-23
DATE REPORTED: 2019-06-18

			SAMPLE DESCRIPTION:	NE2		NE3
			SAMPLE TYPE:	Soil		Soil
			DATE SAMPLED:	2019-05-21		2019-05-21
Parameter	Unit	G / S	RDL	215584	RDL	215585
2,3,7,8-Tetra CDD	ng/kg		0.5	<0.5	0.1	<0.1
1,2,3,7,8-Penta CDD	ng/kg		0.1	<0.1	0.2	<0.2
1,2,3,4,7,8-Hexa CDD	ng/kg		0.4	<0.4	0.3	<0.3
1,2,3,6,7,8-Hexa CDD	ng/kg		0.4	<0.4	0.3	<0.3
1,2,3,7,8,9-Hexa CDD	ng/kg		0.4	<0.4	0.3	<0.3
1,2,3,4,6,7,8-Hepta CDD	ng/kg		0.6	<0.6	0.8	<0.8
Octa CDD	ng/kg		6	23	4	17
2,3,7,8-Tetra CDF	ng/kg		0.2	<0.2	0.4	<0.4
1,2,3,7,8-Penta CDF	ng/kg		0.2	<0.2	0.3	<0.3
2,3,4,7,8-Penta CDF	ng/kg		0.1	<0.1	0.2	<0.2
1,2,3,4,7,8-Hexa CDF	ng/kg		0.1	<0.1	0.2	<0.2
1,2,3,6,7,8-Hexa CDF	ng/kg		0.1	<0.1	0.2	<0.2
2,3,4,6,7,8-Hexa CDF	ng/kg		0.1	<0.1	0.2	<0.2
1,2,3,7,8,9-Hexa CDF	ng/kg		0.2	<0.2	0.4	<0.4
1,2,3,4,6,7,8-Hepta CDF	ng/kg		0.1	<0.1	0.3	<0.3
1,2,3,4,7,8,9-Hepta CDF	ng/kg		0.4	<0.4	0.7	<0.7
Octa CDF	ng/kg		2	<2	2	<2
Total Tetrachlorodibenzodioxins	ng/kg		0.5	1.8	0.1	0.3
Total Pentachlorodibenzodioxins	ng/kg		0.1	0.3	0.2	0.6
Total Hexachlorodibenzodioxins	ng/kg		0.4	<0.4	0.3	<0.3
Total Heptachlorodibenzodioxins	ng/kg		0.6	<0.6	0.8	<0.8
Total PCDDs	ng/kg		6	25	4	19
Total Tetrachlorodibenzofurans	ng/kg		0.2	0.5	0.4	<0.4
Total Pentachlorodibenzofurans	ng/kg		0.2	<0.2	0.3	<0.3
Total Hexachlorodibenzofurans	ng/kg		0.2	<0.2	0.4	<0.4
Total Heptachlorodibenzofurans	ng/kg		0.4	<0.4	0.7	<0.7
Total PCDFs	ng/kg		2	<2	2	<2
2,3,7,8-Tetra CDD (TEF 1.0)	TEQ			0		0
1,2,3,7,8-Penta CDD (TEF 1.0)	TEQ			0		0
1,2,3,4,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0

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CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES
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ATTENTION TO: Heather Daurie
SAMPLED BY:

Dioxins and Furans (Soil, WHO 2005)

DATE RECEIVED: 2019-05-23

DATE REPORTED: 2019-06-18

			SAMPLE DESCRIPTION:	NE2		NE3
			SAMPLE TYPE:	Soil		Soil
			DATE SAMPLED:	2019-05-21		2019-05-21
Parameter	Unit	G / S	RDL	215584	RDL	215585
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	TEQ			0		0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	TEQ			0		0
Octa CDD (TEF 0.0003)	TEQ			0.00683		0.00521
2,3,7,8-Tetra CDF (TEF 0.1)	TEQ			0		0
1,2,3,7,8-Penta CDF (TEF 0.03)	TEQ			0		0
2,3,4,7,8-Penta CDF (TEF 0.3)	TEQ			0		0
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0		0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0		0
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0		0
Octa CDF (TEF 0.0003)	TEQ			0		0
Total PCDDs and PCDFs (TEQ)	ng/kg TEQ			0.00683		0.00521

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Dioxins and Furans (Soil, WHO 2005)

DATE RECEIVED: 2019-05-23

DATE REPORTED: 2019-06-18

		SAMPLE DESCRIPTION:	NE2	NE3
		SAMPLE TYPE:	Soil	Soil
		DATE SAMPLED:	2019-05-21	2019-05-21
Surrogate	Unit	Acceptable Limits	215584	215585
13C-2378-TCDF	%	30-140	46	71
13C-12378-PeCDF	%	30-140	59	62
13C-23478-PeCDF	%	30-140	81	76
13C-123478-HxCDF	%	30-140	77	90
13C-123678-HxCDF	%	30-140	74	77
13C-234678-HxCDF	%	30-140	81	91
13C-123789-HxCDF	%	30-140	81	89
13C-1234678-HpCDF	%	30-140	59	64
13C-1234789-HpCDF	%	30-140	54	57
13C-2378-TCDD	%	30-140	72	80
13C-12378-PeCDD	%	30-140	78	84
13C-123478-HxCDD	%	30-140	89	90
13C-123678-HxCDD	%	30-140	81	90
13C-1234678-HpCDD	%	30-140	60	61
13C-OCDD	%	30-140	30	33

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

215578-215581 The results were corrected based on the surrogate percent recoveries.

215582-215583 The results were corrected based on the surrogate percent recoveries.
The percent recovery of 13C-OCDD is outside of acceptable range due to matrix interferences.

215584-215585 The results were corrected based on the surrogate percent recoveries.

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PROJECT:
SAMPLING SITE:

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Soil Analysis

RPT Date: Jun 18, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Available Metals in Soil															
Aluminum	214857		8290	7340	12.2%	< 10	120%	80%	120%	120%	80%	120%	NA	70%	130%
Antimony	214857		<1	<1	NA	< 1	84%	80%	120%	120%	80%	120%	70%	70%	130%
Arsenic	214857		5	4	NA	< 1	120%	80%	120%	110%	80%	120%	111%	70%	130%
Barium	214857		30	27	7.8%	< 5	120%	80%	120%	115%	80%	120%	NA	70%	130%
Beryllium	214857		<2	<2	NA	< 2	111%	80%	120%	104%	80%	120%	102%	70%	130%
Boron	214857		6	5	NA	< 2	120%	80%	120%	119%	80%	120%	113%	70%	130%
Cadmium	214857		<0.3	<0.3	NA	< 0.3	118%	80%	120%	113%	80%	120%	110%	70%	130%
Chromium	214857		15	15	2.4%	< 2	120%	80%	120%	120%	80%	120%	NA	70%	130%
Cobalt	214857		7	7	2.7%	< 1	113%	80%	120%	110%	80%	120%	NA	70%	130%
Copper	214857		11	11	5.7%	< 2	120%	80%	120%	110%	80%	120%	NA	70%	130%
Iron	214857		10600	14600	NA	< 50	120%	80%	120%	118%	80%	120%	NA	70%	130%
Lead	214857		14.7	15.5	5.2%	< 0.5	111%	80%	120%	107%	80%	120%	NA	70%	130%
Lithium	214857		28	27	4.8%	< 5	130%	70%	130%	118%	70%	130%	NA	70%	130%
Manganese	214857		310	395	NA	< 2	116%	80%	120%	114%	80%	120%	NA	70%	130%
Molybdenum	214857		<2	<2	NA	< 2	96%	80%	120%	98%	80%	120%	110%	70%	130%
Nickel	214857		18	18	1.5%	< 2	116%	80%	120%	113%	80%	120%	NA	70%	130%
Selenium	214857		<1	<1	NA	< 1	120%	80%	120%	113%	80%	120%	72%	70%	130%
Silver	214857		<0.5	<0.5	NA	< 0.5	104%	80%	120%	103%	80%	120%	113%	70%	130%
Strontium	214857		7	8	NA	< 5	106%	80%	120%	105%	80%	120%	121%	70%	130%
Thallium	214857		<0.1	<0.1	NA	< 0.1	112%	80%	120%	106%	80%	120%	70%	70%	130%
Tin	214857		4	4	NA	< 2	114%	80%	120%	118%	80%	120%	106%	70%	130%
Uranium	214857		0.5	0.5	5.1%	< 0.1	108%	80%	120%	103%	80%	120%	117%	70%	130%
Vanadium	214857		19	18	3.7%	< 2	114%	80%	120%	110%	80%	120%	NA	70%	130%
Zinc	214857		65	58	10.6%	< 5	113%	80%	120%	107%	80%	120%	NA	70%	130%
Mercury in Soil															
Mercury	215585	215585	<0.05	<0.05	NA	< 0.05	110%	70%	130%	NA	70%	130%	100%	70%	130%
Methylmercury in Soil															
Methyl Mercury	1	215578	<0.4	<0.4	NA	< 0.4	89%	65%	135%	110%	65%	135%	78%	65%	135%
Grain Size Analysis - Coarse/Fine Classification															
Classification	1	215578				<									
Analyses Inorganiques (sol)															
Carbone organique total	258268		0.6	0.5	NA	< 0.3	116%	80%	120%	NA	80%	120%	119%	80%	120%

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Quality Assurance

CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES
AGAT WORK ORDER: 19X470398
PROJECT:
ATTENTION TO: Heather Daurie
SAMPLING SITE:
SAMPLED BY:

Soil Analysis (Continued)

RPT Date: Jun 18, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper

Comments: NA : Non applicable

NA dans l'écart du duplicata indique que l'écart n'a pu être calculé car l'un ou les deux résultats sont < 5x LDR.

NA dans le pourcentage de récupération de l'échantillon fortifié indique que le résultat n'est pas fourni en raison de l'hétérogénéité de l'échantillon ou de la concentration trop élevée par rapport à l'ajout.

NA dans le blanc fortifié ou le MRC indique qu'il n'est pas requis par la procédure.

La pourcentage de récupération du MRC peut être en dehors du critère d'acceptabilité de 80-120%, s'il est conforme à l'écart du certificat du matériau de référence.

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SAMPLED BY:

Ultra Trace Analysis

RPT Date: Jun 18, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Dioxins and Furans (Soil, WHO 2005)															
2,3,7,8-Tetra CDD	1	215578	< 0.1	< 0.1	NA	< 0.1	107%	30%	140%	NA	30%	140%	122%	30%	140%
1,2,3,7,8-Penta CDD	1	215578	< 0.1	< 0.3	NA	< 0.1	113%	30%	140%	NA	30%	140%	128%	30%	140%
1,2,3,4,7,8-Hexa CDD	1	215578	< 0.3	< 0.3	NA	< 0.1	121%	30%	140%	NA	30%	140%	124%	30%	140%
1,2,3,6,7,8-Hexa CDD	1	215578	< 0.2	< 0.3	NA	< 0.1	121%	30%	140%	NA	30%	140%	122%	30%	140%
1,2,3,7,8,9-Hexa CDD	1	215578	< 0.3	< 0.3	NA	< 0.1	82%	30%	140%	NA	30%	140%	128%	30%	140%
1,2,3,4,6,7,8-Hepta CDD	1	215578	< 0.6	< 0.4	NA	< 0.3	101%	30%	140%	NA	30%	140%	129%	30%	140%
Octa CDD	1	215578	14	12	15.4%	< 2	114%	30%	140%	NA	30%	140%	121%	30%	140%
2,3,7,8-Tetra CDF	1	215578	< 0.2	< 0.1	NA	< 0.1	126%	30%	140%	NA	30%	140%	127%	30%	140%
1,2,3,7,8-Penta CDF	1	215578	< 0.2	< 0.2	NA	< 0.1	104%	30%	140%	NA	30%	140%	120%	30%	140%
2,3,4,7,8-Penta CDF	1	215578	< 0.2	< 0.1	NA	< 0.1	110%	30%	140%	NA	30%	140%	127%	30%	140%
1,2,3,4,7,8-Hexa CDF	1	215578	< 0.3	< 0.2	NA	< 0.1	104%	30%	140%	NA	30%	140%	129%	30%	140%
1,2,3,6,7,8-Hexa CDF	1	215578	< 0.2	< 0.2	NA	< 0.1	121%	30%	140%	NA	30%	140%	117%	30%	140%
2,3,4,6,7,8-Hexa CDF	1	215578	< 0.2	< 0.2	NA	< 0.1	93%	30%	140%	NA	30%	140%	125%	30%	140%
1,2,3,7,8,9-Hexa CDF	1	215578	< 0.4	< 0.3	NA	< 0.2	112%	30%	140%	NA	30%	140%	123%	30%	140%
1,2,3,4,6,7,8-Hepta CDF	1	215578	< 0.5	< 0.1	NA	< 0.3	106%	30%	140%	NA	30%	140%	129%	30%	140%
1,2,3,4,7,8,9-Hepta CDF	1	215578	< 1	< 0.4	NA	< 0.5	126%	30%	140%	NA	30%	140%	128%	30%	140%
Octa CDF	1	215578	< 2	< 2	NA	< 2	113%	30%	140%	NA	30%	140%	119%	30%	140%

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Quality Assurance

CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES

PROJECT:

SAMPLING SITE:

AGAT WORK ORDER: 19X470398

ATTENTION TO: Heather Daurie

SAMPLED BY:

Ultra Trace Analysis

RPT Date: Jun 18, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Dioxins and Furans (Soil, WHO 2005)															
2,3,7,8-Tetra CDD	1	215578	< 0.1	< 0.1	NA	< 0.1	107%	30%	140%	NA	30%	140%	122%	30%	140%
1,2,3,7,8-Penta CDD	1	215578	< 0.1	< 0.3	NA	< 0.1	113%	30%	140%	NA	30%	140%	128%	30%	140%
1,2,3,4,7,8-Hexa CDD	1	215578	< 0.3	< 0.3	NA	< 0.1	121%	30%	140%	NA	30%	140%	124%	30%	140%
1,2,3,6,7,8-Hexa CDD	1	215578	< 0.2	< 0.3	NA	< 0.1	121%	30%	140%	NA	30%	140%	122%	30%	140%
1,2,3,7,8,9-Hexa CDD	1	215578	< 0.3	< 0.3	NA	< 0.1	82%	30%	140%	NA	30%	140%	126%	30%	140%
1,2,3,4,6,7,8-Hepta CDD	1	215578	< 0.6	< 0.4	NA	< 0.3	101%	30%	140%	NA	30%	140%	129%	30%	140%
Octa CDD	1	215578	14	12	15.4%	< 2	114%	30%	140%	NA	30%	140%	121%	30%	140%
2,3,7,8-Tetra CDF	1	215578	< 0.2	< 0.1	NA	< 0.1	126%	30%	140%	NA	30%	140%	127%	30%	140%
1,2,3,7,8-Penta CDF	1	215578	< 0.2	< 0.2	NA	< 0.1	104%	30%	140%	NA	30%	140%	120%	30%	140%
2,3,4,7,8-Penta CDF	1	215578	< 0.2	< 0.1	NA	< 0.1	110%	30%	140%	NA	30%	140%	127%	30%	140%
1,2,3,4,7,8-Hexa CDF	1	215578	< 0.3	< 0.2	NA	< 0.1	104%	30%	140%	NA	30%	140%	129%	30%	140%
1,2,3,6,7,8-Hexa CDF	1	215578	< 0.2	< 0.2	NA	< 0.1	121%	30%	140%	NA	30%	140%	117%	30%	140%
2,3,4,6,7,8-Hexa CDF	1	215578	< 0.2	< 0.2	NA	< 0.1	93%	30%	140%	NA	30%	140%	125%	30%	140%
1,2,3,7,8,9-Hexa CDF	1	215578	< 0.4	< 0.3	NA	< 0.2	112%	30%	140%	NA	30%	140%	123%	30%	140%
1,2,3,4,6,7,8-Hepta CDF	1	215578	< 0.5	< 0.1	NA	< 0.3	106%	30%	140%	NA	30%	140%	129%	30%	140%
1,2,3,4,7,8,9-Hepta CDF	1	215578	< 1	< 0.4	NA	< 0.5	126%	30%	140%	NA	30%	140%	128%	30%	140%
Octa CDF	1	215578	< 2	< 2	NA	< 2	113%	30%	140%	NA	30%	140%	119%	30%	140%

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Method Summary

CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES **AGAT WORK ORDER: 19X470398**
PROJECT: **ATTENTION TO: Heather Daurie**
SAMPLING SITE: **SAMPLED BY:**

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Carbone organique total	INOR-101-6057F	MA. 405-C 1.1	TITRAGE
Aluminum	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Antimony	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Arsenic	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Barium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Beryllium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Boron	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Cadmium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Chromium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Cobalt	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Copper	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Iron	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Lead	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP-MS
Lithium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP-MS
Manganese	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Molybdenum	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Nickel	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Selenium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Silver	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Strontium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Thallium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Tin	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Uranium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Vanadium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Zinc	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Particles >75um	INOR-121-6031, INOR-121-6034	ASTM D-422-63	Sieve
Classification	INOR-121-6031, INOR-121-6031	Atlantic RBCA	Sieve
Mercury	INOR-121-6101 & INOR-121-6107	Based on EPA 245.5 & SM 3112B	CVAA

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Method Summary

CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES **AGAT WORK ORDER: 19X470398**

PROJECT: **ATTENTION TO: Heather Daurie**

SAMPLING SITE: **SAMPLED BY:**

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Ultra Trace Analysis			
2,3,7,8-Tetra CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8-Penta CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8-Hexa CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,6,7,8-Hexa CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8,9-Hexa CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,4,6,7,8-Hepta CDD	HR-151-5400	EPA 1613	HRMS
Octa CDD	HR-151-5400	EPA 1613	HRMS
2,3,7,8-Tetra CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8-Penta CDF	HR-151-5400	EPA 1613	HRMS
2,3,4,7,8-Penta CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8-Hexa CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,6,7,8-Hexa CDF	HR-151-5400	EPA 1613	HRMS
2,3,4,6,7,8-Hexa CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8,9-Hexa CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,4,6,7,8-Hepta CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8,9-Hepta CDF	HR-151-5400	EPA 1613	HRMS
Octa CDF	HR-151-5400	EPA 1613	HRMS
Total Tetrachlorodibenzodioxins	HR-151-5400	EPA 1613	HRMS
Total Pentachlorodibenzodioxins	HR-151-5400	EPA 1613	HRMS
Total Hexachlorodibenzodioxins	HR-151-5400	EPA 1613	HRMS
Total Heptachlorodibenzodioxins	HR-151-5400	EPA 1613	HRMS
Total PCDDs	HR-151-5400	EPA 1613	HRMS
Total Tetrachlorodibenzofurans	HR-151-5400	EPA 1613	HRMS
Total Pentachlorodibenzofurans	HR-151-5400	EPA 1613	HRMS
Total Hexachlorodibenzofurans	HR-151-5400	EPA 1613	HRMS
Total Heptachlorodibenzofurans	HR-151-5400	EPA 1613	HRMS
Total PCDFs	HR-151-5400	EPA 1613	HRMS
2,3,7,8-Tetra CDD (TEF 1.0)	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8-Penta CDD (TEF 1.0)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8-Hexa CDD (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	HR-151-5400	EPA 1613	HRMS
Octa CDD (TEF 0.0003)	HR-151-5400	EPA 1613	HRMS
2,3,7,8-Tetra CDF (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8-Penta CDF (TEF 0.03)	HR-151-5400	EPA 1613	HRMS
2,3,4,7,8-Penta CDF (TEF 0.3)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	HR_151-5400	EPA 1613	HRMS
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	HR-151-5400	EPA 1613	HRMS
Octa CDF (TEF 0.0003)	HR-151-5400	EPA 1613	HRMS
Total PCDDs and PCDFs (TEQ)	HR-151-5400	EPA 1613	HRMS
13C-2378-TCDF	HR-151-5400	EPA 1613	HRMS
13C-12378-PeCDF	HR-151-5400	EPA 1613	HRMS
13C-23478-PeCDF	HR-151-5400	EPA 1613	HRMS
13C-123478-HxCDF	HR-151-5400	EPA 1613	HRMS

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Method Summary

CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES
AGAT WORK ORDER: 19X470398
PROJECT:
ATTENTION TO: Heather Daurie
SAMPLING SITE:
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Ultra Trace Analysis			
2,3,7,8-Tetra CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8-Penta CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8-Hexa CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,6,7,8-Hexa CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8,9-Hexa CDD	HR-151-5400	EPA 1613	HRMS
1,2,3,4,6,7,8-Hepta CDD	HR-151-5400	EPA 1613	HRMS
Octa CDD	HR-151-5400	EPA 1613	HRMS
2,3,7,8-Tetra CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8-Penta CDF	HR-151-5400	EPA 1613	HRMS
2,3,4,7,8-Penta CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8-Hexa CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,6,7,8-Hexa CDF	HR-151-5400	EPA 1613	HRMS
2,3,4,6,7,8-Hexa CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8,9-Hexa CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,4,6,7,8-Hepta CDF	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8,9-Hepta CDF	HR-151-5400	EPA 1613	HRMS
Octa CDF	HR-151-5400	EPA 1613	HRMS
Total Tetrachlorodibenzodioxins	HR-151-5400	EPA 1613	HRMS
Total Pentachlorodibenzodioxins	HR-151-5400	EPA 1613	HRMS
Total Hexachlorodibenzodioxins	HR-151-5400	EPA 1613	HRMS
Total Heptachlorodibenzodioxins	HR-151-5400	EPA 1613	HRMS
Total PCDDs	HR-151-5400	EPA 1613	HRMS
Total Tetrachlorodibenzofurans	HR-151-5400	EPA 1613	HRMS
Total Pentachlorodibenzofurans	HR-151-5400	EPA 1613	HRMS
Total Hexachlorodibenzofurans	HR-151-5400	EPA 1613	HRMS
Total Heptachlorodibenzofurans	HR-151-5400	EPA 1613	HRMS
Total PCDFs	HR-151-5400	EPA 1613	HRMS
2,3,7,8-Tetra CDD (TEF 1.0)	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8-Penta CDD (TEF 1.0)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8-Hexa CDD (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	HR-151-5400	EPA 1613	HRMS
Octa CDD (TEF 0.0003)	HR-151-5400	EPA 1613	HRMS
2,3,7,8-Tetra CDF (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8-Penta CDF (TEF 0.03)	HR-151-5400	EPA 1613	HRMS
2,3,4,7,8-Penta CDF (TEF 0.3)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	HR_151-5400	EPA 1613	HRMS
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	HR-151-5400	EPA 1613	HRMS
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	HR-151-5400	EPA 1613	HRMS
Octa CDF (TEF 0.0003)	HR-151-5400	EPA 1613	HRMS
Total PCDDs and PCDFs (TEQ)	HR-151-5400	EPA 1613	HRMS
13C-2378-TCDF	HR-151-5400	EPA 1613	HRMS
13C-12378-PeCDF	HR-151-5400	EPA 1613	HRMS
13C-23478-PeCDF	HR-151-5400	EPA 1613	HRMS
13C-123478-HxCDF	HR-151-5400	EPA 1613	HRMS

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Method Summary

CLIENT NAME: DALHOUSIE UNIVERSITY - FINANCIAL SERVICES

AGAT WORK ORDER: 10X470308

PROJECT:

ATTENTION TO: Heather Daurie

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
13C-123678-HxCDF	HR-151-5400	EPA 1613	HRMS
13C-234678-HxCDF	HR-151-5400	EPA 1613	HRMS
13C-123789-HxCDF	HR-151-5400	EPA 1613	HRMS
13C-1234678-HpCDF	HR-151-5400	EPA 1613	HRMS
13C-1234789-HpCDF	HR-151-5400	EPA 1613	HRMS
13C-2378-TCDD	HR-151-5400	EPA 1613	HRMS
13C-12378-PeCDD	HR-151-5400	EPA 1613	HRMS
13C-123478-HxCDD	HR-151-5400	EPA 1613	HRMS
13C-123678-HxCDD	HR-151-5400	EPA 1613	HRMS
13C-1234678-HpCDD	HR-151-5400	EPA 1613	HRMS
13C-OCDD	HR-151-5400	EPA 1613	HRMS

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CLIENT NAME: NOVA SCOTIA LANDS INC
PO BOX 430, STATION A
SYDNEY , NS B1P6H2
(902) 564-7933

ATTENTION TO: Tony Walker

PROJECT: Lobster

AGAT WORK ORDER: 18X361283

MISCELLANEOUS ANALYSIS REVIEWED BY: Kelly Hogue, B.Sc, P.Chem, Operations Manager

SOIL ANALYSIS REVIEWED BY: Laura Baker, Inorganics Data Reporter

ULTRA TRACE REVIEWED BY: Philippe Morneau, chimiste

DATE REPORTED: Aug 01, 2018

PAGES (INCLUDING COVER): 24

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (902) 468-8718

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 18X361283
PROJECT: Lobster

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
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FAX (902)468-8924
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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Subcontracted Data Received

DATE RECEIVED: 2018-07-12 — DATE REPORTED: 2018-08-01

		SAMPLE DESCRIPTION:		LOB N1	LOB N2	LOB N8	LOB NE1	LOB NE5	LOB NE8
		SAMPLE TYPE:		Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
		DATE SAMPLED:		2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Parameter	Unit	G / S	RDL	9397190	9397210	9397237	9397254	9397258	9397260
Subcontracted Data				Y	Y	Y	Y	Y	Y

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 18X361283

PROJECT: Lobster

11 Morris Drive, Unit 122
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CLIENT NAME: NOVA SCOTIA LANDS INC

ATTENTION TO: Tony Walker

SAMPLING SITE:

SAMPLED BY:

Metals in Tissue

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-08-01

			SAMPLE DESCRIPTION:	LOB N1	LOB N2	LOB N3	LOB N4	LOB N5	LOB N6	LOB N7	LOB N8
			SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
			DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Parameter	Unit	G / S	RDL	8387190	8387210	8387222	8387224	8387226	8387228	8387235	8387237
Aluminum	mg/kg		10	<10	<10	<10	<10	<10	<10	<10	<10
Antimony	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Arsenic	mg/kg		2	10	8	7	10	10	10	10	4
Barium	mg/kg		5	<5	<5	<5	<5	<5	<5	<5	<5
Beryllium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Bismuth	mg/kg		5	<5	<5	<5	<5	<5	<5	<5	<5
Boron	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Cadmium	mg/kg		0.3	1.0	0.7	1.1	1.3	1.4	0.7	1.1	0.9
Chromium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Cobalt	mg/kg		1	<1	<1	<1	<1	<1	<1	<1	<1
Copper	mg/kg		2	22	20	22	22	28	31	22	13
Iron	mg/kg		50	<50	<50	<50	<50	<50	<50	<50	<50
Lead	mg/kg		0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Manganese	mg/kg		2	3	8	7	6	17	11	14	6
Molybdenum	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Nickel	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Selenium	mg/kg		1	<1	<1	<1	<1	1	1	1	<1
Silver	mg/kg		0.5	0.6	<0.5	0.6	0.6	0.7	0.8	0.6	<0.5
Strontium	mg/kg		5	8	20	17	13	24	37	75	20
Thallium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Uranium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Zinc	mg/kg		5	25	30	32	30	33	34	30	18

Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 18X361283

PROJECT: Lobster

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CLIENT NAME: NOVA SCOTIA LANDS INC

ATTENTION TO: Tony Walker

SAMPLING SITE:

SAMPLED BY:

Metals in Tissue

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-08-01

			SAMPLE DESCRIPTION:	LOB NE1	LOB NE3	LOB NE6	LOB NE7	LOB NE8	LOB N3-Dup	LOB NE6-Dup
			SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
			DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Parameter	Unit	G / S	RDL	8387254	8387256	8387257	8387258	8387260	8408935	8408937
Aluminum	mg/kg		10	<10	<10	<10	<10	<10	<10	<10
Antimony	mg/kg		2	<2	<2	<2	<2	<2	<2	<2
Arsenic	mg/kg		2	7	7	8	7	6	5	6
Barium	mg/kg		5	<5	<5	<5	<5	<5	<5	<5
Beryllium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2
Bismuth	mg/kg		5	<5	<5	<5	<5	<5	<5	<5
Boron	mg/kg		2	<2	<2	3	<2	<2	<2	<2
Cadmium	mg/kg		0.3	1.0	1.2	0.6	1.2	1.1	0.4	1.2
Chromium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2
Cobalt	mg/kg		1	<1	<1	<1	<1	<1	<1	<1
Copper	mg/kg		2	14	14	25	22	21	16	19
Iron	mg/kg		50	<50	<50	<50	<50	<50	<50	<50
Lead	mg/kg		0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Manganese	mg/kg		2	7	11	8	3	6	7	10
Molybdenum	mg/kg		2	<2	<2	<2	<2	<2	<2	<2
Nickel	mg/kg		2	<2	<2	<2	<2	<2	<2	<2
Selenium	mg/kg		1	<1	<1	1	<1	<1	<1	<1
Silver	mg/kg		0.5	<0.5	0.7	0.7	0.5	0.6	<0.5	0.6
Strontium	mg/kg		5	15	26	28	9	14	14	33
Thallium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	mg/kg		2	<2	<2	<2	<2	<2	<2	<2
Uranium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2
Zinc	mg/kg		5	32	33	31	29	34	37	36

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

8387190-8408937 Results are based on the wet weight of the sample.

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 18X361283
PROJECT: Lobster

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: NOVA SCOTIA LANDS INC | **ATTENTION TO: Tony Walker**
SAMPLING SITE: | **SAMPLED BY:**

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 | DATE REPORTED: 2018-08-01

			SAMPLE DESCRIPTION:	LOB N1		LOB N2		LOB N3		LOB N4
			SAMPLE TYPE:	Tissue		Tissue		Tissue		Tissue
			DATE SAMPLED:	2018-07-11		2018-07-11		2018-07-11		2018-07-11
Parameter	**Unit**	**G / S**	**RDL**	**9387190**	**RDL**	**9387210**	**RDL**	**9387222**	**RDL**	**9387224**
2,3,7,8-Tetra CDD	ng/kg		0.2	<0.2	0.5	<0.5	0.2	<0.2	0.4	<0.4
1,2,3,7,8-Penta CDD	ng/kg		0.8	<0.8	0.9	<0.9	0.2	<0.2	0.5	<0.5
1,2,3,4,7,8-Hexa CDD	ng/kg		0.8	<0.8	0.9	<0.9	0.5	<0.5	0.7	<0.7
1,2,3,6,7,8-Hexa CDD	ng/kg		0.7	<0.7	0.9	<0.9	0.4	<0.4	0.6	<0.6
1,2,3,7,8,9-Hexa CDD	ng/kg		0.7	<0.7	0.8	<0.8	0.5	<0.5	0.7	<0.7
1,2,3,4,6,7,8-Hepta CDD	ng/kg		0.6	<0.6	1	<1	0.6	<0.6	1	<1
Octa CDD	ng/kg		2	<2	2	3	0.7	0.7	2	<2
2,3,7,8-Tetra CDF	ng/kg		0.4	0.6	0.2	0.6	0.3	<0.3	0.6	<0.6
1,2,3,7,8-Penta CDF	ng/kg		0.5	<0.5	0.6	<0.6	0.5	<0.5	0.9	<0.9
2,3,4,7,8-Penta CDF	ng/kg		1	<1	0.5	<0.5	0.4	<0.4	0.7	0.9
1,2,3,4,7,8-Hexa CDF	ng/kg		0.2	<0.2	0.8	<0.8	0.5	<0.5	0.5	<0.5
1,2,3,6,7,8-Hexa CDF	ng/kg		0.2	<0.2	0.9	<0.9	0.5	<0.5	0.6	<0.6
2,3,4,6,7,8-Hexa CDF	ng/kg		03	<03	0.8	<0.8	0.5	<0.5	0.6	<0.6
1,2,3,7,8,9-Hexa CDF	ng/kg		0.3	<0.3	1	<1	0.8	<0.8	0.8	<0.8
1,2,3,4,6,7,8-Hepta CDF	ng/kg		0.6	<0.6	1	<1	0.2	<0.2	1	<1
1,2,3,4,7,8,9-Hepta CDF	ng/kg		0.9	<0.9	1	<1	0.4	<0.4	2	<2
Octa CDF	ng/kg		2	<2	4	<4	2	<2	2	<2
Total Tetrachlorodibenzodioxins	ng/kg		0.2	1.0	0.5	1.2	0.2	0.4	0.4	1.5
Total Pentachlorodibenzodioxins	ng/kg		0.8	2.7	0.9	3.1	0.2	0.4	0.5	<0.5
Total Hexachlorodibenzodioxins	ng/kg		0.8	2.8	0.9	3.7	0.5	1.3	0.7	2.8
Total Heptachlorodibenzodioxins	ng/kg		0.6	1.6	1	6	0.6	0.7	1	<1
Total PCDDs	ng/kg		2	8	2	17	0.7	3.6	2	6
Total Tetrachlorodibenzofurans	ng/kg		0.4	3.9	0.2	5.7	0.3	3.3	0.6	4.0
Total Pentachlorodibenzofurans	ng/kg		1	4	0.6	4.1	0.5	2.5	0.9	4.2
Total Hexachlorodibenzofurans	ng/kg		0.3	1.4	1	2	0.8	1.0	0.8	1.6
Total Heptachlorodibenzofurans	ng/kg		0.9	<0.9	1	2	0.4	<0.4	2	<2
Total PCDFs	ng/kg		2	9	4	14	2	7	2	11
2,3,7,8-Tetra CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,7,8-Penta CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0

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Certificate of Analysis

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CLIENT NAME: NOVA SCOTIA LANDS INC | **ATTENTION TO: Tony Walker**
SAMPLING SITE: | **SAMPLED BY:**

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 | DATE REPORTED: 2018-08-01

			SAMPLE DESCRIPTION:	LOB N1		LOB N2		LOB N3		LOB N4
			SAMPLE TYPE:	Tissue		Tissue		Tissue		Tissue
			DATE SAMPLED:	2018-07-11		2018-07-11		2018-07-11		2018-07-11
Parameter	**Unit**	**G / S**	**RDL**	**9387190**	**RDL**	**9387210**	**RDL**	**9387222**	**RDL**	**9387224**
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	TEQ			0		0		0		0
Octa CDD (TEF 0.0003)	TEQ			0		0.000912		0.000213		0
2,3,7,8-Tetra CDF (TEF 0.1)	TEQ			0.0557		0.0589		0		0
1,2,3,7,8-Penta CDF (TEF 0.03)	TEQ			0		0		0		0
2,3,4,7,8-Penta CDF (TEF 0.3)	TEQ			0		0		0		0.255
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
Octa CDF (TEF 0.0003)	TEQ			0		0		0		0
Total PCDDs and PCDFs (TEQ)	TEQ			0.0557		0.0598		0.000213		0.255

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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
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Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 **DATE REPORTED: 2018-08-01**

		SAMPLE DESCRIPTION:	LOB N1	LOB N2	LOB N3	LOB N4
		SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue
		DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Surrogate	Unit	Acceptable Limits	9387190	9387210	9387222	9387224
13C-2378-TCDF	%	30-140	64	41	53	58
13C-12378-PeCDF	%	30-140	57	38	46	54
13C-23478-PeCDF	%	30-140	44	45	56	63
13C-123478-HxCDF	%	30-140	64	49	57	67
13C-123678-HxCDF	%	30-140	74	51	78	74
13C-234678-HxCDF	%	30-140	68	56	75	1
13C-123789-HxCDF	%	30-140	64	50	57	64
13C-1234678-HpCDF	%	30-140	50	40	54	52
13C-1234789-HpCDF	%	30-140	49	42	41	53
13C-2378-TCDD	%	30-140	82	51	61	75
13C-12378-PeCDD	%	30-140	35	48	56	65
13C-123478-HxCDD	%	30-140	69	57	65	73
13C-123678-HxCDD	%	30-140	77	59	98	73
13C-1234678-HpCDD	%	30-140	53	48	50	57
13C-OCDD	%	30-140	38	34	36	41

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Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 **DATE REPORTED: 2018-08-01**

			SAMPLE DESCRIPTION:	LOB N5		LOB N6		LOB N7		LOB N8
			SAMPLE TYPE:	Tissue		Tissue		Tissue		Tissue
			DATE SAMPLED:	2018-07-11		2018-07-11		2018-07-11		2018-07-11
Parameter	Unit	G / S	RDL	9387226	RDL	9387228	RDL	9387235	RDL	9387237
2,3,7,8-Tetra CDD	ng/kg		0.4	<0.4	0.2	<0.2	0.4	<0.4	0.5	<0.5
1,2,3,7,8-Penta CDD	ng/kg		0.4	<0.4	0.8	<0.8	2	<2	0.6	<0.6
1,2,3,4,7,8-Hexa CDD	ng/kg		0.5	<0.5	1	<1	1	<1	0.8	<0.8
1,2,3,6,7,8-Hexa CDD	ng/kg		0.5	<0.5	0.9	<0.9	1	<1	1	<1
1,2,3,7,8,9-Hexa CDD	ng/kg		0.5	<0.5	1	<1	1	<1	0.8	<0.8
1,2,3,4,6,7,8-Hepta CDD	ng/kg		0.6	<0.6	0.6	<0.6	3	<3	3	<3
Octa CDD	ng/kg		1	<1	2	<2	8	<8	6	<6
2,3,7,8-Tetra CDF	ng/kg		0.5	0.8	0.4	0.9	0.8	2.1	0.8	1.1
1,2,3,7,8-Penta CDF	ng/kg		0.6	<0.6	0.8	<0.8	2	<2	0.9	<0.9
2,3,4,7,8-Penta CDF	ng/kg		0.5	<0.5	0.6	<0.6	2	<2	0.7	<0.7
1,2,3,4,7,8-Hexa CDF	ng/kg		0.5	<0.5	0.9	<0.9	1	<1	1	1
1,2,3,6,7,8-Hexa CDF	ng/kg		0.5	<0.5	0.9	<0.9	1	<1	1	<1
2,3,4,6,7,8-Hexa CDF	ng/kg		0.5	<0.5	1	<1	1	<1	1	<1
1,2,3,7,8,9-Hexa CDF	ng/kg		0.7	<0.7	2	<2	2	<2	1	<1
1,2,3,4,6,7,8-Hepta CDF	ng/kg		0.4	0.5	1	<1	2	<2	0.9	1.3
1,2,3,4,7,8,9-Hepta CDF	ng/kg		0.6	<0.6	2	<2	3	<3	2	<2
Octa CDF	ng/kg		1	<1	3	<3	2	<2	6	<6
Total Tetrachlorodibenzodioxins	ng/kg		0.4	1.1	0.2	0.2	0.4	1.7	0.5	0.6
Total Pentachlorodibenzodioxins	ng/kg		0.4	1.1	0.8	1.3	2	<2	0.6	0.8
Total Hexachlorodibenzodioxins	ng/kg		0.5	1.9	1	2	1	4	1	3
Total Heptachlorodibenzodioxins	ng/kg		.6	1.8	0.6	0.7	3	<3	3	<3
Total PCDDs	ng/kg		1	6	2	4	8	<8	6	6
Total Tetrachlorodibenzofurans	ng/kg		0.5	5.0	0.4	3.3	0.8	7.1	0.8	2.9
Total Pentachlorodibenzofurans	ng/kg		0.6	2.3	0.8	1.8	2	2	0.9	1.6
Total Hexachlorodibenzofurans	ng/kg		0.7	1.2	2	2	2	2	1	2
Total Heptachlorodibenzofurans	ng/kg		0.6	2.1	2	2	3	4	2	<2
Total PCDFs	ng/kg		1	11	3	9	3	16	6	8
2,3,7,8-Tetra CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,7,8-Penta CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0

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Certificate of Analysis

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PROJECT: Lobster

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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 | DATE REPORTED: 2018-08-01

		SAMPLE DESCRIPTION:		LOB N5		LOB N6		LOB N7		LOB N8
		SAMPLE TYPE:		Tissue		Tissue		Tissue		Tissue
		DATE SAMPLED:		2018-07-11		2018-07-11		2018-07-11		2018-07-11
Parameter	Unit	G / S	RDL	9397226	RDL	9397228	RDL	9397235	RDL	9397237
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	TEQ			0		0		0		0
Octa CDD (TEF 0.0003)	TEQ			0		0		0		0
2,3,7,8-Tetra CDF (TEF 0.1)	TEQ			0.0760		0.0878		0.205		0.114
1,2,3,7,8-Penta CDF (TEF 0.03)	TEQ			0		0		0		0
2,3,4,7,8-Penta CDF (TEF 0.3)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0.119
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0.00478		0		0		0.0133
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
Octa CDF (TEF 0.0003)	TEQ			0		0		0		0
Total PCDDs and PCDFs (TEQ)	TEQ			0.0808		0.0878		0.205		0.246

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SAMPLING SITE:

ATTENTION TO: Tony Walker
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Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 | DATE REPORTED: 2018-08-01

		SAMPLE DESCRIPTION:	LOB N5	LOB N6	LOB N7	LOB N8
		SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue
		DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Surrogate	Unit	Acceptable Limits	9397226	9397228	9397235	9397237
13C-2378-TCDF	%	30-140	49	58	41	44
13C-12378-PeCDF	%	30-140	45	47	39	39
13C-23478-PeCDF	%	30-140	48	63	39	51
13C-123478-HxCDF	%	30-140	62	70	63	58
13C-123678-HxCDF	%	30-140	62	83	65	65
13C-234678-HxCDF	%	30-140	62	74	63	56
13C-123789-HxCDF	%	30-140	58	61	54	40
13C-1234678-HpCDF	%	30-140	50	56	45	44
13C-1234789-HpCDF	%	30-140	50	53	44	37
13C-2378-TCDD	%	30-140	65	75	55	54
13C-12378-PeCDD	%	30-140	58	63	44	48
13C-123478-HxCDD	%	30-140	74	73	60	55
13C-123678-HxCDD	%	30-140	75	86	73	69
13C-1234678-HpCDD	%	30-140	56	61	45	41
13C-OCDD	%	30-140	42	36	39	32

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ATTENTION TO: Tony Walker
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-08-01

		SAMPLE DESCRIPTION:		LOB NE1		LOB NE3		LOB NE6		LOB NE7
		SAMPLE TYPE:		Tissue		Tissue		Tissue		Tissue
		DATE SAMPLED:		2018-07-11		2018-07-11		2018-07-11		2018-07-11
Parameter	Unit	G / S	RDL	8387264	RDL	8387266	RDL	8387267	RDL	8387268
2,3,7,8-Tetra CDD	ng/kg		0.2	<0.2	0.2	<0.2	0.3	<0.3	0.4	<0.4
1,2,3,7,8-Penta CDD	ng/kg		0.4	<0.4	0.3	<0.3	2	<2	0.9	<0.9
1,2,3,4,7,8-Hexa CDD	ng/kg		0.4	<0.4	0.4	<0.4	1	1	0.8	<0.8
1,2,3,6,7,8-Hexa CDD	ng/kg		0.4	<0.4	0.4	<0.4	0.9	<0.9	0.6	<0.6
1,2,3,7,8,9-Hexa CDD	ng/kg		0.4	<0.4	0.4	<0.4	1	<1	0.7	<0.7
1,2,3,4,6,7,8-Hepta CDD	ng/kg		0.6	<0.6	0.6	<0.6	2	<2	0.9	<0.9
Octa CDD	ng/kg		2	<2	3	<3	1	2	3	4
2,3,7,8-Tetra CDF	ng/kg		0.3	0.5	0.2	0.4	0.4	<0.4	0.4	1.3
1,2,3,7,8-Penta CDF	ng/kg		0.3	0.4	0.5	<0.5	2	<2	1	<1
2,3,4,7,8-Penta CDF	ng/kg		0.2	0.3	0.4	<0.4	2	<2	1	<1
1,2,3,4,7,8-Hexa CDF	ng/kg		0.4	<0.4	0.5	<0.5	0.8	3.6	1	1
1,2,3,6,7,8-Hexa CDF	ng/kg		0.4	<0.4	0.5	<0.5	0.7	<0.7	0.9	<0.9
2,3,4,6,7,8-Hexa CDF	ng/kg		0.3	<0.3	0.5	<0.5	0.8	<0.8	1	<1
1,2,3,7,8,9-Hexa CDF	ng/kg		0.5	<0.5	0.8	<0.8	1	<1	2	<2
1,2,3,4,6,7,8-Hepta CDF	ng/kg		0.5	0.6	0.8	<0.8	0.9	1.6	1	1
1,2,3,4,7,8,9-Hepta CDF	ng/kg		0.9	<0.9	1	<1	1	<1	2	<2
Octa CDF	ng/kg		1	<1	2	<2	10	<10	3	5
Total Tetrachlorodibenzodioxins	ng/kg		0.2	0.6	0.2	1.2	0.3	0.7	0.4	1.7
Total Pentachlorodibenzodioxins	ng/kg		0.4	0.5	0.3	0.8	2	<2	0.9	2.2
Total Hexachlorodibenzodioxins	ng/kg		0.4	1.3	0.4	1.3	1	4	0.8	2.7
Total Heptachlorodibenzodioxins	ng/kg		0.6	0.9	0.6	<0.6	2	3	0.9	2.0
Total PCDDs	ng/kg		2	3	3	4	2	10	3	13
Total Tetrachlorodibenzofurans	ng/kg		0.3	2.9	0.2	2.7	0.4	7.1	0.4	6.4
Total Pentachlorodibenzofurans	ng/kg		0.3	2.5	0.5	2.1	2	5	1	7
Total Hexachlorodibenzofurans	ng/kg		0.5	0.6	0.8	0.9	1	6	2	5
Total Heptachlorodibenzofurans	ng/kg		0.9	2.5	1	1	1	4	2	6
Total PCDFs	ng/kg		1	8	2	7	10	21	3	29
2,3,7,8-Tetra CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,7,8-Penta CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0.101		0

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Certificate of Analysis

AGAT WORK ORDER: 18X361283
PROJECT: Lobster

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-08-01

		SAMPLE DESCRIPTION:		LOB NE1		LOB NE3		LOB NE6		LOB NE7
		SAMPLE TYPE:		Tissue		Tissue		Tissue		Tissue
		DATE SAMPLED:		2018-07-11		2018-07-11		2018-07-11		2018-07-11
Parameter	Unit	G / S	RDL	8387264	RDL	8387266	RDL	8387267	RDL	8387268
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	TEQ			0		0		0		0
Octa CDD (TEF 0.0003)	TEQ			0		0		0.000709		0.00125
2,3,7,8-Tetra CDF (TEF 0.1)	TEQ			0.0451		0.0404		0.0662		0.133
1,2,3,7,8-Penta CDF (TEF 0.03)	TEQ			0.0112		0		0		0
2,3,4,7,8-Penta CDF (TEF 0.3)	TEQ			0.0823		0		0		0
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0.360		0.114
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0.00634		0		0.0156		0.0139
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
Octa CDF (TEF 0.0003)	TEQ			0		0		0		0.00152
Total PCDDs and PCDFs (TEQ)	TEQ			0.145		0.0404		0.544		0.263

Certificate of Analysis

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PROJECT: Lobster

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CLIENT NAME: NOVA SCOTIA LANDS INC | **ATTENTION TO: Tony Walker**
SAMPLING SITE: | **SAMPLED BY:**

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 | **DATE REPORTED: 2018-08-01**

		SAMPLE DESCRIPTION:	LOB NE1	LOB NE3	LOB NE6	LOB NE7
		SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue
		DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Surrogate	Unit	Acceptable Limits	9397254	9397256	9397257	9397258
13C-2378-TCDF	%	30-140	47	48	57	64
13C-12378-PeCDF	%	30-140	43	46	46	60
13C-23478-PeCDF	%	30-140	47	48	66	40
13C-123478-HxCDF	%	30-140	59	59	69	63
13C-123678-HxCDF	%	30-140	65	60	87	80
13C-234678-HxCDF	%	30-140	66	61	74	74
13C-123789-HxCDF	%	30-140	57	53	59	65
13C-1234678-HpCDF	%	30-140	49	45	46	55
13C-1234789-HpCDF	%	30-140	49	44	36	52
13C-2378-TCDD	%	30-140	62	65	69	80
13C-12378-PeCDD	%	30-140	53	54	62	49
13C-123478-HxCDD	%	30-140	68	68	67	70
13C-123678-HxCDD	%	30-140	76	71	92	88
13C-1234678-HpCDD	%	30-140	55	50	47	58
13C-OCDD	%	30-140	41	33	32	35

Certificate of Analysis

AGAT WORK ORDER: 18X361283
PROJECT: Lobster

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CLIENT NAME: NOVA SCOTIA LANDS INC | **ATTENTION TO: Tony Walker**
SAMPLING SITE: | **SAMPLED BY:**

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 | **DATE REPORTED: 2018-08-01**

			SAMPLE DESCRIPTION:	LOB NE8		LOB N3-Dup		LOB NE6-Dup
			SAMPLE TYPE:	Tissue		Tissue		Tissue
			DATE SAMPLED:	2018-07-11		2018-07-11		2018-07-11
Parameter	Unit	G / S	RDL	9397280	RDL	9408936	RDL	9408937
2,3,7,8-Tetra CDD	ng/kg		0.3	<0.3	0.5	<0.5	0.4	<0.4
1,2,3,7,8-Penta CDD	ng/kg		0.5	<0.5	1	<1	0.5	<0.5
1,2,3,4,7,8-Hexa CDD	ng/kg		0.5	<0.5	2	<2	1	<1
1,2,3,6,7,8-Hexa CDD	ng/kg		0.5	<0.5	2	<2	0.9	<0.9
1,2,3,7,8,9-Hexa CDD	ng/kg		0.5	<0.5	2	<2	1	<1
1,2,3,4,6,7,8-Hepta CDD	ng/kg		0.6	<0.6	1	2	2	<2
Octa CDD	ng/kg		1	1	7	<7	2	<2
2,3,7,8-Tetra CDF	ng/kg		0.4	0.6	0.7	<0.7	0.8	<0.8
1,2,3,7,8-Penta CDF	ng/kg		0.6	<0.6	0.9	<0.9	0.8	<0.8
2,3,4,7,8-Penta CDF	ng/kg		0.5	<0.5	0.7	<0.7	0.6	<0.6
1,2,3,4,7,8-Hexa CDF	ng/kg		0.5	0.6	1	<1	0.7	<0.7
1,2,3,6,7,8-Hexa CDF	ng/kg		0.4	<0.4	0.8	<0.8	0.8	1.0
2,3,4,6,7,8-Hexa CDF	ng/kg		0.5	<0.5	1	<1	0.8	0.9
1,2,3,7,8,9-Hexa CDF	ng/kg		0.7	<0.7	1	<1	1	<1
1,2,3,4,6,7,8-Hepta CDF	ng/kg		0.5	<0.5	1	<1	0.8	<0.8
1,2,3,4,7,8,9-Hepta CDF	ng/kg		0.6	<0.6	2	<2	1	<1
Octa CDF	ng/kg		2	2	3	<3	10	<10
Total Tetrachlorodibenzodioxins	ng/kg		0.3	0.6	0.5	1.1	0.4	0.6
Total Pentachlorodibenzodioxins	ng/kg		0.5	0.7	1	2	0.5	0.7
Total Hexachlorodibenzodioxins	ng/kg		0.5	2.1	2	<2	1	2
Total Heptachlorodibenzodioxins	ng/kg		0.6	1.3	1	4	2	<2
Total PCDDs	ng/kg		1	6	7	9	2	3
Total Tetrachlorodibenzofurans	ng/kg		0.4	3.2	0.7	5.5	0.8	3.5
Total Pentachlorodibenzofurans	ng/kg		0.6	2.2	0.9	2.0	0.8	1.3
Total Hexachlorodibenzofurans	ng/kg		0.7	1.3	1	4	1	3
Total Heptachlorodibenzofurans	ng/kg		0.6	0.8	2	<2	1	<1
Total PCDFs	ng/kg		2	9	3	14	10	<10
2,3,7,8-Tetra CDD (TEF 1.0)	TEQ			0		0		0
1,2,3,7,8-Penta CDD (TEF 1.0)	TEQ			0		0		0
1,2,3,4,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 18X361283
PROJECT: Lobster

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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-08-01

		SAMPLE DESCRIPTION:		LOB NE8		LOB N3-Dup		LOB NE8-Dup
		SAMPLE TYPE:		Tissue		Tissue		Tissue
		DATE SAMPLED:		2018-07-11		2018-07-11		2018-07-11
Parameter	**Unit**	**G / S**	**RDL**	**8387280**	**RDL**	**8408836**	**RDL**	**8408837**
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	TEQ			0		0		0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	TEQ			0		0.0171		0
Octa CDD (TEF 0.0003)	TEQ			0.000372		0		0
2,3,7,8-Tetra CDF (TEF 0.1)	TEQ			0.0622		0		0
1,2,3,7,8-Penta CDF (TEF 0.03)	TEQ			0		0		0
2,3,4,7,8-Penta CDF (TEF 0.3)	TEQ			0		0		0
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0.0558		0		0
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0.092
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0.0882
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0		0		0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0		0		0
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0		0		0
Octa CDF (TEF 0.0003)	TEQ			0.000505		0		0
Total PCDDs and PCDFs (TEQ)	TEQ			0.119		0.0171		0.187

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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-08-01

		SAMPLE DESCRIPTION:	LOB NE8	LOB N3-Dup	LOB NE8-Dup
		SAMPLE TYPE:	Tissue	Tissue	Tissue
		DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11
Surrogate	**Unit**	**Acceptable Limits**	**8387280**	**8408836**	**8408837**
13C-2378-TCDF	%	30-140	40	42	50
13C-12378-PeCDF	%	30-140	38	34	45
13C-23478-PeCDF	%	30-140	40	40	57
13C-123478-HxCDF	%	30-140	53	53	65
13C-123678-HxCDF	%	30-140	57	63	77
13C-234678-HxCDF	%	30-140	54	58	65
13C-123789-HxCDF	%	30-140	50	54	57
13C-1234678-HpCDF	%	30-140	42	43	49
13C-1234789-HpCDF	%	30-140	45	50	43
13C-2378-TCDD	%	30-140	53	53	63
13C-12378-PeCDD	%	30-140	46	41	56
13C-123478-HxCDD	%	30-140	61	65	69
13C-123678-HxCDD	%	30-140	67	66	86
13C-1234678-HpCDD	%	30-140	48	54	54
13C-OCDD	%	30-140	33	36	35

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
8387190-8408837 The results were corrected based on the surrogate percent recoveries.

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Quality Assurance

CLIENT NAME: NOVA SCOTIA LANDS INC

PROJECT: Lobster

SAMPLING SITE:

AGAT WORK ORDER: 18X361283

ATTENTION TO: Tony Walker

SAMPLED BY:

Soil Analysis

RPT Date: Aug 01, 2018			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Mercury Analysis in Tissue															
Mercury in Tissue	1	9397256	<0.05	<0.05	NA	< 0.05	87%	70%	130%	NA	70%	130%	95%	70%	130%
Metals in Tissue															
Aluminum	9406935	9406935	<10	<10	NA	< 10	104%	70%	130%	102%	70%	130%	NA	70%	130%
Antimony	9406935	9406935	<2	<2	NA	< 2	85%	70%	130%	104%	70%	130%	NA	70%	130%
Arsenic	9406935	9406935	5	5	NA	< 2	95%	70%	130%	94%	70%	130%	NA	70%	130%
Barium	9406935	9406935	<5	<5	NA	< 5	94%	70%	130%	94%	70%	130%	NA	70%	130%
Beryllium	9406935	9406935	<2	<2	NA	< 2	103%	70%	130%	100%	70%	130%	NA	70%	130%
Bismuth	9406935	9406935	<5	<5	NA	< 5	101%	70%	130%	NA	130%	130%	NA	70%	130%
Boron	9406935	9406935	<2	<2	NA	< 2	102%	70%	130%	103%	70%	130%	NA	70%	130%
Cadmium	9406935	9406935	0.4	0.4	NA	< 0.3	93%	70%	130%	95%	70%	130%	NA	70%	130%
Chromium	9406935	9406935	<2	<2	NA	< 2	99%	70%	130%	98%	70%	130%	NA	70%	130%
Cobalt	9406935	9406935	<1	<1	NA	< 1	102%	70%	130%	101%	70%	130%	NA	70%	130%
Copper	9406935	9406935	15	15	2.2%	< 2	102%	70%	130%	101%	70%	130%	NA	70%	130%
Iron	9406935	9406935	<50	<50	NA	< 50	105%	70%	130%	106%	70%	130%	NA	70%	130%
Lead	9406935	9406935	<0.4	<0.4	NA	< 0.4	108%	70%	130%	107%	70%	130%	NA	70%	130%
Manganese	9406935	9406935	7	4	NA	< 2	111%	70%	130%	112%	70%	130%	NA	70%	130%
Molybdenum	9406935	9406935	<2	<2	NA	< 2	96%	90%	110%	97%	90%	110%	NA	70%	130%
Nickel	9406935	9406935	<2	<2	NA	< 2	101%	70%	130%	99%	70%	130%	NA	70%	130%
Selenium	9406935	9406935	<1	<1	NA	< 1	97%	70%	130%	94%	70%	130%	NA	70%	130%
Silver	9406935	9406935	<0.5	<0.5	NA	< 0.5	100%	70%	130%	101%	70%	130%	NA	70%	130%
Strontium	9406935	9406935	14	8	NA	< 5	103%	70%	130%	105%	70%	130%	NA	70%	130%
Thallium	9406935	9406935	<0.1	<0.1	NA	< 0.1	102%	70%	130%	101%	70%	130%	NA	70%	130%
Tin	9406935	9406935	<2	<2	NA	< 2	93%	70%	130%	95%	70%	130%	NA	70%	130%
Uranium	9406935	9406935	<0.1	<0.1	NA	< 0.1	101%	70%	130%	99%	70%	130%	NA	70%	130%
Vanadium	9406935	9406935	<2	<2	NA	< 2	98%	70%	130%	98%	70%	130%	NA	70%	130%
Zinc	9406935	9406935	37	36	4.8%	< 5	99%	70%	130%	102%	70%	130%	NA	70%	130%

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Quality Assurance

CLIENT NAME: NOVA SCOTIA LANDS INC | AGAT WORK ORDER: 18X361283
PROJECT: Lobster | ATTENTION TO: Tony Walker
SAMPLING SITE: | SAMPLED BY:

Ultra Trace Analysis

RPT Date: Aug 01, 2018			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Dioxins and Furans (Tissue, WHO 2005)															
2,3,7,8-Tetra CDD	1	9387224	< 0.4	< 0.3	NA	< 0.1	93%	40%	130%	NA	40%	130%	83%	40%	130%
1,2,3,7,8-Penta CDD	1	9387224	< 0.5	< 0.7	NA	< 0.2	89%	40%	130%	NA	40%	130%	98%	40%	130%
1,2,3,4,7,8-Hexa CDD	1	9387224	< 0.7	< 0.8	NA	< 0.2	93%	40%	130%	NA	40%	130%	94%	40%	130%
1,2,3,6,7,8-Hexa CDD	1	9387224	< 0.6	< 0.8	NA	< 0.1	96%	40%	130%	NA	40%	130%	99%	40%	130%
1,2,3,7,8,9-Hexa CDD	1	9387224	< 0.7	< 0.7	NA	< 0.1	94%	40%	130%	NA	40%	130%	100%	40%	130%
1,2,3,4,6,7,8-Hepta CDD	1	9387224	< 1	< 1	NA	< 0.6	92%	40%	130%	NA	40%	130%	91%	40%	130%
Octa CDD	1	9387224	< 2	< 2	NA	< 0.4	92%	40%	130%	NA	40%	130%	90%	40%	130%
2,3,7,8-Tetra CDF	1	9387224	< 0.6	< 0.5	NA	< 0.1	99%	40%	130%	NA	40%	130%	99%	40%	130%
1,2,3,7,8-Penta CDF	1	9387224	< 0.9	< 1	NA	< 0.2	103%	40%	130%	NA	40%	130%	104%	40%	130%
2,3,4,7,8-Penta CDF	1	9387224	0.9	< 0.8	NA	< 0.1	109%	40%	130%	NA	40%	130%	108%	40%	130%
1,2,3,4,7,8-Hexa CDF	1	9387224	< 0.5	< 0.7	NA	< 0.2	103%	40%	130%	NA	40%	130%	108%	40%	130%
1,2,3,6,7,8-Hexa CDF	1	9387224	< 0.6	< 0.6	NA	< 0.2	96%	40%	130%	NA	40%	130%	104%	40%	130%
2,3,4,6,7,8-Hexa CDF	1	9387224	< 0.6	< 0.6	NA	< 0.2	106%	40%	130%	NA	40%	130%	105%	40%	130%
1,2,3,7,8,9-Hexa CDF	1	9387224	< 0.8	< 0.9	NA	< 0.2	94%	40%	130%	NA	40%	130%	103%	40%	130%
1,2,3,4,6,7,8-Hepta CDF	1	9387224	< 1	< 2	NA	< 0.2	102%	40%	130%	NA	40%	130%	106%	40%	130%
1,2,3,4,7,8,9-Hepta CDF	1	9387224	< 2	< 3	NA	< 0.2	95%	40%	130%	NA	40%	130%	104%	40%	130%
Octa CDF	1	9387224	< 2	< 3	NA	< 0.3	85%	40%	130%	NA	40%	130%	91%	40%	130%

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 18X361283
PROJECT: Lobster

11 Morris Drive, Unit 122
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CANADA B3B 1M2
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FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: NOVA SCOTIA LANDS INC | ATTENTION TO: Tony Walker
SAMPLING SITE: | SAMPLED BY:

Mercury Analysis in Tissue

DATE RECEIVED: 2018-07-12 | DATE REPORTED: 2018-08-01

			SAMPLE DESCRIPTION:	LOB N1	LOB N2	LOB N3	LOB N4	LOB N5	LOB N6	LOB N7	LOB N8
			SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
			DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Parameter	Unit	G / S	RDL	9387190	9387210	9387222	9387224	9387226	9387228	9387236	9387237
Mercury in Tissue	mg/kg		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

			SAMPLE DESCRIPTION:	LOB NE1	LOB NE3	LOB NE6	LOB NE7	LOB NE8	LOB N3-Dup	LOB NE6-Dup
			SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
			DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Parameter	Unit	G / S	RDL	9387254	9387256	9387257	9387258	9387260	9406836	9406837
Mercury in Tissue	mg/kg		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9387190-9406837 Results are based on the wet weight of the sample.

Methyl Mercury Results

Flett Research Ltd.

440 DeSalaberry Ave. Winnipeg, MB R2L 0Y7
[illegible]
E-mail: flett@flettresearch.ca Webpage: http://www.flettresearch.ca

CLIENT: AGAT Labs - Dartmouth: 18x361283
Unit 122-11 Morris Drive
Dartmouth, NS B3B 1M2

Date Received: July 24, 2018
Sampling Date: July 11, 2018

Matrix: Tissue (wet)
Transaction ID: 718
PO/Contract No.:
Date Analysed: July 27, 2018
Analyst(s): Xiang W.

Analytical Method: M10220. Methyl Mercury in Tissue by Digestion, Aqueous Ethylation, Purge & Trap, and CVAFS with an Automated System (Version 3)

Comments: Samples are wet tissues which were homogenized at AGAT.

Detection Limit: 4 ng/g (ML) MDL = 1 ng/g The MDL was determined based on 7 replicates of analytical blanks (99% confidence level) and a 100 mg wet sample size.

For reporting purposes results will be flagged below the ML which is considered a practical quantitation limit.

Estimated Uncertainty: The estimated uncertainty of this method has been determined to be ± 13% at a concentration level of 4470 ng/g (95% confidence)

Results authorized by: Dr. Robert J. Flett, Chief Scientist

QUALITY DATA

Blanks		pg of MeHg in whole ethylation EPA vial	Gross Peak Area	Mean Ethylation Blank (ng/L)
	Ethylation blank (H_2O+Reagent)	0.42	1422	0.01
	Mean Eth. Blank (last 30 runs)	0.30		0.01
		Net pg MeHg in whole Ethylation EPA vial	Gross Peak Area	Equiv. CH_3Hg Conc. based on current batch mean weight (0.0989g) of wet sample, ng/g (Note)
	Method Blank 1	-0.30	397	-0.289
	Method Blank 2	-0.29	407	-0.287
	Method Blank 3	0.01	1448	0.007
	Mean Method Blank	-0.20		-0.190
Standards		MeHg Standard Added to Ethylation EPA Vial (pg CH_3Hg)	Gross Peak Area	Net Corrected MeHg Std Calibration Factor (units / pg)
	Mean Value			5759

Spike Recovery	Sample Identification	Sample Type	Gross Peak Area	% CH_3Hg Recovery Used for Calculations	Wet Sample Mass (g)	Net CH_3Hg as Hg (ng/g Wet Wt)	CH_3Hg Recovery (%)
	[illegible] (LOB N8)	MS	220430	100%	0.101	98	85.7
	[illegible] (LOB N8)	MSD	222613	100%	0.098	87	96.5
	Mean of Recoveries						91.1
QC Samples	Dorm-4 ID1501 (355± 26 ng/g)		321882	100%	0.025		95.3
	Dorm-4 ID1501 (355± 26 ng/g)	Repeat Aliquot	313604	100%	0.025		92.9
	Mean of Dorm-4						94.1
[illegible]	A.S.S. - Alfa ID1302 (1000 ng/L)		185406	100%		[illegible]	109.7

LAB ID	Sampling Details	Sample ID	Date Sampled	Sample Type	Gross Peak Area	% CH_3Hg Recovery Used for Calculations	Weighed Wet Sample Mass (g)	Net CH_3Hg as Hg (ng/g) Wet Wt. [recovery corrected]
[illegible]	[illegible]	LOB N1	July 11, 2018		140111	91.1	0.1086	37.3
[illegible]	[illegible]	LOB N2	July 11, 2018		122080	91.1	0.0944	53.4
[illegible]	[illegible]	LOB N8	July 11, 2018		31698	91.1	0.0969	15.3
[illegible]	[illegible]	LOB N81	July 11, 2018		186240	91.1	0.1102	41.8
[illegible]	[illegible]	LOB N83	July 11, 2018		182158	91.1	0.1064	47.2
[illegible]	[illegible]	LOB N88	July 11, 2018	Dup#1	87810	91.1	0.0807	30.3
[illegible]	[illegible]	LOB N88	July 11, 2018	Dup#2	88560	91.1	0.0844	32.7

* : See 'Comments' section above for discussion.

[illegible]

This test report shall not be reproduced, except in full, without written approval of the laboratory.
Note: Results relate only to the items tested.

Dup : Duplicate - two subsamples of the same sample carried through the analytical procedure in an identical manner.

CALA

[illegible]

AGAT Laboratories

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
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TEL (902)468-8718
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http://www.agatlabs.com

CLIENT NAME: NOVA SCOTIA LANDS INC
PO BOX 430, STATION A
SYDNEY , NS B1P6H2
(902) 564-7933

ATTENTION TO: Tony Walker

PROJECT:

AGAT WORK ORDER: 18X361280

MISCELLANEOUS ANALYSIS REVIEWED BY: Kelly Hogue, B.Sc, P.Chem, Operations Manager

SOIL ANALYSIS REVIEWED BY: Laura Baker, Inorganics Data Reporter

ULTRA TRACE REVIEWED BY: Philippe Morneau, chimiste

DATE REPORTED: Aug 01, 2018

PAGES (INCLUDING COVER): 25

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (902) 468-8718

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 18X361280
PROJECT:

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CLIENT NAME: NOVA SCOTIA LANDS INC **ATTENTION TO:** Tony Walker
SAMPLING SITE: **SAMPLED BY:**

Subcontracted Data Received

DATE RECEIVED: 2018-07-12 **DATE REPORTED: 2018-08-01**

			SAMPLE DESCRIPTION:	CNE1	CNE2	CNE8	C N8	C N3	C N2
			SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
			DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Parameter	Unit	G / S	RDL	8387166	8387168	8387180	8387188	8387188	8387189
Subcontracted Data				Y	Y	Y	Y	Y	Y

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 18X361280
PROJECT:

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http://www.agatlabs.com

CLIENT NAME: NOVA SCOTIA LANDS INC | **ATTENTION TO: Tony Walker**
SAMPLING SITE: | **SAMPLED BY:**

Mercury Analysis in Tissue

DATE RECEIVED: 2018-07-12 | DATE REPORTED: 2018-08-01

			SAMPLE DESCRIPTION:	CNE1	CNE2	CNE3	CNE5	CNE6	CNE7	CNE8	C N8
			SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
			DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Parameter	Unit	G / S	RDL	8387166	8387168	8387169	8387172	8387173	8387174	8387180	8387188
Mercury in Tissue	mg/kg		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

			SAMPLE DESCRIPTION:	C N7	C N6	C N4	C N3	C N2
			SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue	Tissue
			DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Parameter	Unit	G / S	RDL	8387182	8387183	8387184	8387186	8387189
Mercury in Tissue	mg/kg		0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
8387166-8387189 Results are based on the wet weight of the sample.

Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 18X361280
PROJECT:

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CLIENT NAME: NOVA SCOTIA LANDS INC | **ATTENTION TO: Tony Walker**
SAMPLING SITE: | **SAMPLED BY:**

Metals in Tissue

DATE RECEIVED: 2018-07-12 | DATE REPORTED: 2018-08-01

			SAMPLE DESCRIPTION:	CNE1	CNE2	CNE3	CNE5	CNE6	CNE7	CNE8	C N8
			SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
			DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Parameter	Unit	G / S	RDL	8387166	8387168	8387169	8387172	8387173	8387174	8387180	8387188
Aluminum	mg/kg		10	18	<10	10	32	40	<10	33	14
Antimony	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Arsenic	mg/kg		2	3	5	2	5	5	5	3	5
Barium	mg/kg		5	<5	<5	<5	<5	<5	<5	<5	<5
Beryllium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Bismuth	mg/kg		5	<5	<5	<5	<5	<5	<5	<5	<5
Boron	mg/kg		2	<2	<2	2	<2	<2	<2	<2	2
Cadmium	mg/kg		0.3	0.4	0.5	0.9	1.6	0.8	0.7	2.9	3.9
Chromium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Cobalt	mg/kg		1	<1	<1	<1	<1	<1	<1	<1	<1
Copper	mg/kg		2	12	18	20	19	16	16	30	23
Iron	mg/kg		50	<50	<50	<50	60	82	<50	63	<50
Lead	mg/kg		0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Manganese	mg/kg		2	4	4	8	11	8	7	10	6
Molybdenum	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Nickel	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Selenium	mg/kg		1	<1	2	<1	2	1	1	1	2
Silver	mg/kg		0.5	<0.5	0.6	<0.5	0.6	0.6	<0.5	0.9	0.8
Strontium	mg/kg		5	25	36	20	61	50	91	25	50
Thallium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Uranium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Zinc	mg/kg		5	24	36	28	39	35	34	27	39

Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 18X361280
PROJECT:

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CLIENT NAME: NOVA SCOTIA LANDS INC
ATTENTION TO: Tony Walker
SAMPLING SITE:
SAMPLED BY:

Metals in Tissue

DATE RECEIVED: 2018-07-12
DATE REPORTED: 2018-08-01

Parameter	Unit	G / S	RDL	C N7	C N8	C N4	C N3	C N2
SAMPLE TYPE:				Tissue	Tissue	Tissue	Tissue	Tissue
DATE SAMPLED:				2018-07-11	2018-07-11	2018-07-11	2018-07-11	2018-07-11
				9387192	9387193	9387194	9387198	9387199
Aluminum	mg/kg		10	10	20	50	17	<10
Antimony	mg/kg		2	<2	<2	<2	<2	<2
Arsenic	mg/kg		2	5	4	4	4	4
Barium	mg/kg		5	<5	<5	<5	<5	<5
Beryllium	mg/kg		2	<2	<2	<2	<2	<2
Bismuth	mg/kg		5	<5	<5	<5	<5	<5
Boron	mg/kg		2	<2	<2	2	<2	<2
Cadmium	mg/kg		0.3	0.6	0.8	1.6	0.8	1.0
Chromium	mg/kg		2	<2	<2	<2	<2	<2
Cobalt	mg/kg		1	<1	<1	<1	<1	<1
Copper	mg/kg		2	16	20	36	18	12
Iron	mg/kg		50	<50	59	95	51	<50
Lead	mg/kg		0.4	<0.4	<0.4	<0.4	0.9	<0.4
Manganese	mg/kg		2	4	14	17	6	5
Molybdenum	mg/kg		2	<2	<2	<2	<2	<2
Nickel	mg/kg		2	<2	<2	<2	<2	<2
Selenium	mg/kg		1	2	1	1	1	1
Silver	mg/kg		0.5	0.5	0.6	1.0	0.6	<0.5
Strontium	mg/kg		5	38	95	29	43	38
Thallium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	mg/kg		2	<2	<2	<2	<2	<2
Uranium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	mg/kg		2	<2	<2	<2	<2	<2
Zinc	mg/kg		5	37	34	26	42	39

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9387166-9387199 Results are based on the wet weight of the sample.

Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 18X361280
PROJECT:

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: NOVA SCOTIA LANDS INC
ATTENTION TO: Tony Walker
SAMPLING SITE:
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12
DATE REPORTED: 2018-08-01

Parameter	Unit	G / S	RDL	CNE1	RDL	CNE2	RDL	CNE3	RDL	CNE5
SAMPLE TYPE:				Tissue		Tissue		Tissue		Tissue
DATE SAMPLED:				2018-07-11		2018-07-11		2018-07-11		2018-07-11
				9387166		9387168		9387169		9387172
2,3,7,8-Tetra CDD	ng/kg		0.4	<0.4	0.2	<0.2	0.2	<0.2	0.6	<0.6
1,2,3,7,8-Penta CDD	ng/kg		0.4	<0.4	0.4	<0.4	0.5	<0.5	0.6	<0.6
1,2,3,4,7,8-Hexa CDD	ng/kg		0.5	<0.5	0.3	<0.3	0.5	<0.5	0.9	<0.9
1,2,3,6,7,8-Hexa CDD	ng/kg		0.4	<0.4	0.2	<0.2	0.4	<0.4	0.8	<0.8
1,2,3,7,8,9-Hexa CDD	ng/kg		0.4	<0.4	0.3	<0.3	0.4	<0.4	0.8	<0.8
1,2,3,4,6,7,8-Hepta CDD	ng/kg		0.5	<0.5	0.6	<0.6	1	1	1	<1
Octa CDD	ng/kg		1	<1	0.7	0.7	0.9	1.2	1	2
2,3,7,8-Tetra CDF	ng/kg		0.3	<0.3	0.3	<0.3	0.3	<0.3	0.5	0.6
1,2,3,7,8-Penta CDF	ng/kg		0.3	<0.3	0.4	<0.4	0.2	<0.2	0.7	<0.7
2,3,4,7,8-Penta CDF	ng/kg		0.2	<0.2	0.3	<0.3	0.2	<0.2	0.6	<0.6
1,2,3,4,7,8-Hexa CDF	ng/kg		0.5	<0.5	0.6	<0.6	0.3	<0.3	0.5	0.6
1,2,3,6,7,8-Hexa CDF	ng/kg		0.4	<0.4	0.5	<0.5	0.3	<0.3	0.4	<0.4
2,3,4,6,7,8-Hexa CDF	ng/kg		0.5	<0.5	0.5	<0.5	0.3	<0.3	0.4	<0.4
1,2,3,7,8,9-Hexa CDF	ng/kg		0.8	<0.8	0.9	<0.9	0.5	<0.5	0.7	<0.7
1,2,3,4,6,7,8-Hepta CDF	ng/kg		0.4	<0.4	0.4	<0.4	0.4	<0.4	0.9	<0.9
1,2,3,4,7,8,9-Hepta CDF	ng/kg		0.6	<0.6	0.6	<0.6	0.6	<0.6	1	<1
Octa CDF	ng/kg		1	<1	0.9	<0.9	2	<2	3	<3
Total Tetrachlorodibenzodioxins	ng/kg		0.4	0.6	0.2	<0.2	0.2	1.7	0.6	2.0
Total Pentachlorodibenzodioxins	ng/kg		0.4	0.5	0.4	0.8	0.5	1.8	0.6	1.6
Total Hexachlorodibenzodioxins	ng/kg		0.5	1.5	0.3	1.0	0.5	5.0	0.9	3.1
Total Heptachlorodibenzodioxins	ng/kg		0.5	1.0	0.6	1.0	1	3	1	6
Total PCDDs	ng/kg		1	4	0.7	3.4	1	13	2	14
Total Tetrachlorodibenzofurans	ng/kg		0.3	0.9	0.3	1.4	0.3	0.9	0.5	5.9
Total Pentachlorodibenzofurans	ng/kg		0.3	1.2	0.4	2.7	0.2	0.6	0.7	3.6
Total Hexachlorodibenzofurans	ng/kg		0.8	0.9	0.9	1.0	0.5	0.7	0.7	2.3
Total Heptachlorodibenzofurans	ng/kg		0.6	0.7	0.6	<0.6	0.6	0.8	1	5
Total PCDFs	ng/kg		1	3.7	0.9	5.3	2	3	3	17
2,3,7,8-Tetra CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,7,8-Penta CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0

Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 18X361280

PROJECT:

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CLIENT NAME: NOVA SCOTIA LANDS INC

SAMPLING SITE:

ATTENTION TO: Tony Walker

SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 **DATE REPORTED: 2018-08-01**

			SAMPLE DESCRIPTION:	CNE1		CNE2		CNE3		CNE5
			SAMPLE TYPE:	Tissue		Tissue		Tissue		Tissue
			DATE SAMPLED:	2018-07-11		2018-07-11		2018-07-11		2018-07-11
Parameter	**Unit**	**G / S**	**RDL**	**9387166**	**RDL**	**9387168**	**RDL**	**9387169**	**RDL**	**9387172**
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	TEQ			0		0		0		0
Octa CDD (TEF 0.0003)	TEQ			0		0.000207		0.0125		0.000539
2,3,7,8-Tetra CDF (TEF 0.1)	TEQ			0		0		0.000358		0.0599
1,2,3,7,8-Penta CDF (TEF 0.03)	TEQ			0		0		0		0
2,3,4,7,8-Penta CDF (TEF 0.3)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0.0597
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
Octa CDF (TEF 0.0003)	TEQ			0		0		0		0
Total PCDDs and PCDFs (TEQ)	TEQ			0		0.000207		0.0129		0.120

Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 18X361280

PROJECT:

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: NOVA SCOTIA LANDS INC

SAMPLING SITE:

ATTENTION TO: Tony Walker

SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 DATE REPORTED: 2018-08-01

			SAMPLE DESCRIPTION:	CNE1		CNE2		CNE3		CNE5
			SAMPLE TYPE:	Tissue		Tissue		Tissue		Tissue
			DATE SAMPLED:	2018-07-11		2018-07-11		2018-07-11		2018-07-11
Parameter	Unit	G / S	RDL	9387166	RDL	9387168	RDL	9387169	RDL	9387172
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	TEQ			0		0		0		0
Octa CDD (TEF 0.0003)	TEQ			0		0.000207		0.0125		0.000539
2,3,7,8-Tetra CDF (TEF 0.1)	TEQ			0		0		0.000358		0.0599
1,2,3,7,8-Penta CDF (TEF 0.03)	TEQ			0		0		0		0
2,3,4,7,8-Penta CDF (TEF 0.3)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0.0597
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
Octa CDF (TEF 0.0003)	TEQ			0		0		0		0
Total PCDDs and PCDFs (TEQ)	TEQ			0		0.000207		0.0129		0.120

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 18X361280
PROJECT:

11 Morris Drive, Unit 122
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CLIENT NAME: NOVA SCOTIA LANDS INC
ATTENTION TO: Tony Walker
SAMPLING SITE:
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12
DATE REPORTED: 2018-08-01

Surrogate	Unit	Acceptable Limits	CNE1	CNE2	CNE3	CNE5
		SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue
		DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11
			9397168	9397168	9397169	9397172
13C-2378-TCDF	%	30-140	51	108	55	55
13C-12378-PeCDF	%	30-140	48	71	50	51
13C-23478-PeCDF	%	30-140	64	64	59	60
13C-123478-HxCDF	%	30-140	56	54	65	63
13C-123678-HxCDF	%	30-140	82	76	98	61
13C-234678-HxCDF	%	30-140	69	74	81	70
13C-123789-HxCDF	%	30-140	61	60	64	59
13C-1234678-HpCDF	%	30-140	54	51	58	47
13C-1234789-HpCDF	%	30-140	45	40	49	43
13C-2378-TCDD	%	30-140	44	40	68	68
13C-12378-PeCDD	%	30-140	39	52	62	64
13C-123478-HxCDD	%	30-140	68	66	74	74
13C-123678-HxCDD	%	30-140	98	95	107	69
13C-1234678-HpCDD	%	30-140	53	46	59	52
13C-OCDD	%	30-140	36	34	35	35

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Certificate of Analysis

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CLIENT NAME: NOVA SCOTIA LANDS INC
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SAMPLING SITE:
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12
DATE REPORTED: 2018-08-01

Parameter	Unit	G / S	RDL	CNE6	RDL	CNE7	RDL	CNE8	RDL	C N8
			SAMPLE TYPE:	Tissue		Tissue		Tissue		Tissue
			DATE SAMPLED:	2018-07-11		2018-07-11		2018-07-11		2018-07-11
				9397173		9397174		9397180		9397188
2,3,7,8-Tetra CDD	ng/kg		0.2	<0.2	0.3	<0.3	0.4	<0.4	0.3	<0.3
1,2,3,7,8-Penta CDD	ng/kg		0.4	<0.4	1	<1	0.5	<0.5	0.4	<0.4
1,2,3,4,7,8-Hexa CDD	ng/kg		0.7	<0.7	0.6	<0.6	0.4	0.4	0.3	<0.3
1,2,3,6,7,8-Hexa CDD	ng/kg		0.6	<0.6	0.5	<0.5	0.4	<0.4	0.3	<0.3
1,2,3,7,8,9-Hexa CDD	ng/kg		0.6	<0.6	0.6	<0.6	0.4	<0.4	0.3	<0.3
1,2,3,4,6,7,8-Hepta CDD	ng/kg		0.9	<0.9	1	<1	0.5	<0.5	0.6	0.6
Octa CDD	ng/kg		2	<2	1	<1	2	<2	1	<1
2,3,7,8-Tetra CDF	ng/kg		0.3	<0.3	0.4	0.7	0.4	<0.4	0.4	<0.4
1,2,3,7,8-Penta CDF	ng/kg		0.4	<0.4	0.6	<0.6	0.4	<0.4	0.7	<0.7
2,3,4,7,8-Penta CDF	ng/kg		0.3	<0.3	2	<2	0.3	<0.3	0.6	<0.6
1,2,3,4,7,8-Hexa CDF	ng/kg		0.4	<0.4	0.6	<0.6	0.3	<0.3	0.3	0.3
1,2,3,6,7,8-Hexa CDF	ng/kg		0.3	<0.3	0.5	<0.5	0.2	<0.2	0.3	<0.3
2,3,4,6,7,8-Hexa CDF	ng/kg		0.3	<0.3	0.6	<0.6	0.2	<0.2	0.3	<0.3
1,2,3,7,8,9-Hexa CDF	ng/kg		0.5	<0.5	0.8	<0.8	0.5	<0.5	0.4	<0.4
1,2,3,4,6,7,8-Hepta CDF	ng/kg		0.4	<0.4	1	<1	0.6	<0.6	0.4	<0.4
1,2,3,4,7,8,9-Hepta CDF	ng/kg		0.7	1.0	2	<2	1	<1	0.6	<0.6
Octa CDF	ng/kg		2	<2	2	<2	0.4	0.8	2	<2
Total Tetrachlorodibenzodioxins	ng/kg		0.2	<0.2	0.3	1.5	0.4	<0.4	0.3	3.6
Total Pentachlorodibenzodioxins	ng/kg		0.4	0.7	1	2	0.5	1.1	0.4	1.1
Total Hexachlorodibenzodioxins	ng/kg		0.7	<0.7	0.6	2.7	0.4	1.1	0.3	0.9
Total Heptachlorodibenzodioxins	ng/kg		0.9	1.5	1	4	0.5	0.6	0.6	0.6
Total PCDDs	ng/kg		2	2	1	10	2	3	1	6.2
Total Tetrachlorodibenzofurans	ng/kg		0.3	<0.3	0.4	3.0	0.4	<0.4	0.4	<0.4
Total Pentachlorodibenzofurans	ng/kg		0.4	0.7	2	3.3	0.4	0.4	0.7	1.2
Total Hexachlorodibenzofurans	ng/kg		0.5	0.5	0.8	2.6	0.5	<0.5	0.4	0.9
Total Heptachlorodibenzofurans	ng/kg		0.7	1.7	2	6	1	<1	0.6	1.0
Total PCDFs	ng/kg		2	3	2	15	1	1	2	3
2,3,7,8-Tetra CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,7,8-Penta CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0.0430		0

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Certificate of Analysis

AGAT WORK ORDER: 18X361280

PROJECT:

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
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CLIENT NAME: NOVA SCOTIA LANDS INC | **ATTENTION TO: Tony Walker**

SAMPLING SITE: | **SAMPLED BY:**

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 | **DATE REPORTED: 2018-08-01**

			SAMPLE DESCRIPTION:	CNE6		CNE7		CNE8		C N8
			SAMPLE TYPE:	Tissue		Tissue		Tissue		Tissue
			DATE SAMPLED:	2018-07-11		2018-07-11		2018-07-11		2018-07-11
Parameter	Unit	G / S	RDL	9397173	RDL	9397174	RDL	9397180	RDL	9397188
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	TEQ			0		0		0		0.00572
Octa CDD (TEF 0.0003)	TEQ			0		0		0		0
2,3,7,8-Tetra CDF (TEF 0.1)	TEQ			0		0.0659		0		0
1,2,3,7,8-Penta CDF (TEF 0.03)	TEQ			0		0		0		0
2,3,4,7,8-Penta CDF (TEF 0.3)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0.0302
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0.00950		0		0		0
Octa CDF (TEF 0.0003)	TEQ			0		0		0.000246		0
Total PCDDs and PCDFs (TEQ)	TEQ			0.00950		0.0659		0.0433		0.0360

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 18X361280

PROJECT:

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
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CLIENT NAME: NOVA SCOTIA LANDS INC | **ATTENTION TO: Tony Walker**

SAMPLING SITE: | **SAMPLED BY:**

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 | **DATE REPORTED: 2018-08-01**

		SAMPLE DESCRIPTION:	CNE6	CNE7	CNE8	C N8
		SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue
		DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Surrogate	Unit	Acceptable Limits	9397173	9397174	9397180	9397188
13C-2378-TCDF	%	30-140	33	75	33	44
13C-12378-PeCDF	%	30-140	48	66	33	33
13C-23478-PeCDF	%	30-140	51	35	37	32
13C-123478-HxCDF	%	30-140	40	72	49	46
13C-123678-HxCDF	%	30-140	49	77	71	66
13C-234678-HxCDF	%	30-140	51	71	72	63
13C-123789-HxCDF	%	30-140	45	66	51	52
13C-1234678-HpCDF	%	30-140	35	45	46	41
13C-1234789-HpCDF	%	30-140	30	48	39	34
13C-2378-TCDD	%	30-140	30	91	99	34
13C-12378-PeCDD	%	30-140	30	66	38	41
13C-123478-HxCDD	%	30-140	50	73	63	52
13C-123678-HxCDD	%	30-140	63	80	95	80
13C-1234678-HpCDD	%	30-140	36	51	44	36
13C-OCDD	%	30-140	30	33	30	30

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CLIENT NAME: NOVA SCOTIA LANDS INC **ATTENTION TO: Tony Walker**
SAMPLING SITE: **SAMPLED BY:**

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 **DATE REPORTED: 2018-08-01**

			SAMPLE DESCRIPTION:	C N7		C N8		C N4		C N3
			SAMPLE TYPE:	Tissue		Tissue		Tissue		Tissue
			DATE SAMPLED:	2018-07-11		2018-07-11		2018-07-11		2018-07-11
Parameter	Unit	G / S	RDL	8387182	RDL	8387183	RDL	8387184	RDL	8387188
2,3,7,8-Tetra CDD	ng/kg		0.3	<0.3	0.5	<0.5	0.2	<0.2	0.2	<0.2
1,2,3,7,8-Penta CDD	ng/kg		0.8	<0.8	0.4	<0.4	0.7	<0.7	0.4	<0.4
1,2,3,4,7,8-Hexa CDD	ng/kg		0.5	<0.5	0.7	<0.7	0.5	0.6	0.3	<0.3
1,2,3,6,7,8-Hexa CDD	ng/kg		0.5	<0.5	0.7	<0.7	0.5	<0.5	0.2	<0.2
1,2,3,7,8,9-Hexa CDD	ng/kg		0.5	<0.5	0.7	<0.7	0.5	<0.5	0.2	<0.2
1,2,3,4,6,7,8-Hepta CDD	ng/kg		0.7	<0.7	1	<1	0.6	<0.6	0.5	<0.5
Octa CDD	ng/kg		3	3	2	<2	2	<2	1	1
2,3,7,8-Tetra CDF	ng/kg		0.5	<0.5	0.1	0.2	0.2	<0.2	0.3	0.5
1,2,3,7,8-Penta CDF	ng/kg		0.5	<0.5	0.6	<0.6	0.5	<0.5	0.4	<0.4
2,3,4,7,8-Penta CDF	ng/kg		0.4	0.6	0.5	<0.5	0.4	<0.4	0.3	<0.3
1,2,3,4,7,8-Hexa CDF	ng/kg		0.5	<0.5	0.6	<0.6	0.5	<0.5	0.4	<0.4
1,2,3,6,7,8-Hexa CDF	ng/kg		0.5	<0.5	0.6	<0.6	0.5	<0.5	0.4	<0.4
2,3,4,6,7,8-Hexa CDF	ng/kg		0.5	<0.5	0.5	<0.5	0.5	<0.5	0.4	<0.4
1,2,3,7,8,9-Hexa CDF	ng/kg		0.7	<0.7	1	<1	0.7	<0.7	0.6	<0.6
1,2,3,4,6,7,8-Hepta CDF	ng/kg		1	<1	0.9	<0.9	0.6	0.6	0.4	<0.4
1,2,3,4,7,8,9-Hepta CDF	ng/kg		1	<1	1	<1	0.9	<0.9	0.6	<0.6
Octa CDF	ng/kg		2	<2	2	<2	2	<2	0.8	<0.8
Total Tetrachlorodibenzodioxins	ng/kg		0.3	1.6	0.5	0.6	0.2	0.4	0.2	0.2
Total Pentachlorodibenzodioxins	ng/kg		0.8	1.7	0.4	1.9	0.7	1.4	0.4	1.0
Total Hexachlorodibenzodioxins	ng/kg		0.5	1.1	0.7	2.8	0.5	1.9	0.3	1.2
Total Heptachlorodibenzodioxins	ng/kg		0.7	<0.7	1	3	0.6	1.5	0.5	0.7
Total PCDDs	ng/kg		3	8	2	8	2	5	1	4
Total Tetrachlorodibenzofurans	ng/kg		0.5	5.2	0.1	3.7	0.2	<0.2	0.3	2.5
Total Pentachlorodibenzofurans	ng/kg		0.5	3.7	0.6	0.9	0.5	0.8	0.4	1.1
Total Hexachlorodibenzofurans	ng/kg		0.7	1.8	1	1	0.7	0.8	0.6	0.9
Total Heptachlorodibenzofurans	ng/kg		1	2	1	3	0.9	1.8	0.6	0.6
Total PCDFs	ng/kg		2	12	2	9	2	3	0.8	5.1
2,3,7,8-Tetra CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,7,8-Penta CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0.0581		0

Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 18X361280
PROJECT:

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CLIENT NAME: NOVA SCOTIA LANDS INC **ATTENTION TO: Tony Walker**
SAMPLING SITE: **SAMPLED BY:**

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 **DATE REPORTED: 2018-08-01**

			SAMPLE DESCRIPTION:	C N7		C N8		C N4		C N3
			SAMPLE TYPE:	Tissue		Tissue		Tissue		Tissue
			DATE SAMPLED:	2018-07-11		2018-07-11		2018-07-11		2018-07-11
Parameter	Unit	G / S	RDL	8387182	RDL	8387183	RDL	8387184	RDL	8387188
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	TEQ			0		0		0		0
Octa CDD (TEF 0.0003)	TEQ			0.000934		0		0		0.000357
2,3,7,8-Tetra CDF (TEF 0.1)	TEQ			0		0.0197		0		0.0500
1,2,3,7,8-Penta CDF (TEF 0.03)	TEQ			0		0		0		0
2,3,4,7,8-Penta CDF (TEF 0.3)	TEQ			0.186		0		0		0
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0		0		0.00613		0
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
Octa CDF (TEF 0.0003)	TEQ			0		0		0		0
Total PCDDs and PCDFs (TEQ)	TEQ			0.187		0.0197		0.0642		0.0503

AGAT Laboratories

Certificate of Analysis

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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:
ATTENTION TO: Tony Walker
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12
DATE REPORTED: 2018-08-01

		SAMPLE DESCRIPTION:	C N7	C N6	C N4	C N3
		SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue
		DATE SAMPLED:	2018-07-11	2018-07-11	2018-07-11	2018-07-11
Surrogate	Unit	Acceptable Limits	9387192	9387193	9387194	9387198
13C-2378-TCDF	%	30-140	34	66	64	61
13C-12378-PeCDF	%	30-140	30	55	48	60
13C-23478-PeCDF	%	30-140	34	74	57	66
13C-123478-HxCDF	%	30-140	49	67	58	59
13C-123678-HxCDF	%	30-140	52	79	59	64
13C-234678-HxCDF	%	30-140	52	112	60	62
13C-123789-HxCDF	%	30-140	49	86	55	65
13C-1234678-HpCDF	%	30-140	36	54	47	56
13C-1234789-HpCDF	%	30-140	41	53	46	47
13C-2378-TCDD	%	30-140	45	84	67	79
13C-12378-PeCDD	%	30-140	38	76	63	76
13C-123478-HxCDD	%	30-140	53	99	63	62
13C-123678-HxCDD	%	30-140	59	122	69	76
13C-1234678-HpCDD	%	30-140	45	59	52	55
13C-OCDD	%	30-140	31	35	38	32

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 18X361280
PROJECT:

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:
ATTENTION TO: Tony Walker
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12
DATE REPORTED: 2018-08-01

			SAMPLE DESCRIPTION:	C N2
			SAMPLE TYPE:	Tissue
			DATE SAMPLED:	2018-07-11
Parameter	Unit	G / S	RDL	9387199
2,3,7,8-Tetra CDD	ng/kg		0.2	<0.2
1,2,3,7,8-Penta CDD	ng/kg		0.4	<0.4
1,2,3,4,7,8-Hexa CDD	ng/kg		0.3	<0.3
1,2,3,6,7,8-Hexa CDD	ng/kg		0.2	<0.2
1,2,3,7,8,9-Hexa CDD	ng/kg		0.3	<0.3
1,2,3,4,6,7,8-Hepta CDD	ng/kg		0.9	<0.9
Octa CDD	ng/kg		3	<3
2,3,7,8-Tetra CDF	ng/kg		0.4	<0.4
1,2,3,7,8-Penta CDF	ng/kg		0.4	<0.4
2,3,4,7,8-Penta CDF	ng/kg		0.3	<0.3
1,2,3,4,7,8-Hexa CDF	ng/kg		0.4	<0.4
1,2,3,6,7,8-Hexa CDF	ng/kg		0.3	<0.3
2,3,4,6,7,8-Hexa CDF	ng/kg		0.3	<0.3
1,2,3,7,8,9-Hexa CDF	ng/kg		0.6	<0.6
1,2,3,4,6,7,8-Hepta CDF	ng/kg		0.4	<0.4
1,2,3,4,7,8,9-Hepta CDF	ng/kg		0.6	<0.6
Octa CDF	ng/kg		2	<2
Total Tetrachlorodibenzodioxins	ng/kg		0.2	<0.2
Total Pentachlorodibenzodioxins	ng/kg		0.4	0.8
Total Hexachlorodibenzodioxins	ng/kg		0.3	0.5
Total Heptachlorodibenzodioxins	ng/kg		0.9	0.9
Total PCDDs	ng/kg		3	<3
Total Tetrachlorodibenzofurans	ng/kg		0.4	<0.4
Total Pentachlorodibenzofurans	ng/kg		0.4	1.5
Total Hexachlorodibenzofurans	ng/kg		0.6	0.8
Total Heptachlorodibenzofurans	ng/kg		0.6	0.6
Total PCDFs	ng/kg		2	3
2,3,7,8-Tetra CDD (TEF 1.0)	TEQ			0
1,2,3,7,8-Penta CDD (TEF 1.0)	TEQ			0
1,2,3,4,7,8-Hexa CDD (TEF 0.1)	TEQ			0

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Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 **DATE REPORTED: 2018-08-01**

Parameter	Unit	G / S	RDL	C N2
			SAMPLE TYPE:	Tissue
			DATE SAMPLED:	2018-07-11
				9397199
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	TEQ			0
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	TEQ			0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	TEQ			0
Octa CDD (TEF 0.0003)	TEQ			0
2,3,7,8-Tetra CDF (TEF 0.1)	TEQ			0
1,2,3,7,8-Penta CDF (TEF 0.03)	TEQ			0
2,3,4,7,8-Penta CDF (TEF 0.3)	TEQ			0
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0
Octa CDF (TEF 0.0003)	TEQ			0
Total PCDDs and PCDFs (TEQ)	TEQ			0

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Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 **DATE REPORTED: 2018-08-01**

Surrogate	Unit	Acceptable Limits	C N2
		SAMPLE TYPE:	Tissue
		DATE SAMPLED:	2018-07-11
			9397199
13C-2378-TCDF	%	30-140	36
13C-12378-PeCDF	%	30-140	32
13C-23478-PeCDF	%	30-140	50
13C-123478-HxCDF	%	30-140	44
13C-123678-HxCDF	%	30-140	60
13C-234678-HxCDF	%	30-140	55
13C-123789-HxCDF	%	30-140	40
13C-1234678-HpCDF	%	30-140	34
13C-1234789-HpCDF	%	30-140	34
13C-2378-TCDD	%	30-140	48
13C-12378-PeCDD	%	30-140	72
13C-123478-HxCDD	%	30-140	52
13C-123678-HxCDD	%	30-140	75
13C-1234678-HpCDD	%	30-140	32
13C-OCDD	%	30-140	30

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9397199-9397199 The results were corrected based on the surrogate percent recoveries.

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Quality Assurance

CLIENT NAME: NOVA SCOTIA LANDS INC
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 18X361280
ATTENTION TO: Tony Walker
SAMPLED BY:

Soil Analysis

RPT Date: Aug 01, 2018

PARAMETER	Batch	Sample Id	DUPLICATE Dup #1	Dup #2	RPD	Method Blank	REFERENCE MATERIAL Measured Value	Acceptable Limits Lower	Upper	METHOD BLANK SPIKE Recovery	Acceptable Limits Lower	Upper	MATRIX SPIKE Recovery	Acceptable Limits Lower	Upper
Mercury Analysis in Tissue															
Mercury in Tissue	1	9397199	<0.05	<0.05	NA	< 0.05	74%	70%	130%	NA	70%	130%	90%	70%	130%
Metals in Tissue															
Aluminum	9397199	9397199	<10	<10	NA	< 10	100%	70%	130%	105%	70%	130%	NA	70%	130%
Antimony	9397199	9397199	<2	<2	NA	< 2	90%	70%	130%	105%	70%	130%	NA	70%	130%
Arsenic	9397199	9397199	4	5	NA	< 2	95%	70%	130%	96%	70%	130%	NA	70%	130%
Barium	9397199	9397199	<5	<5	NA	< 5	101%	70%	130%	102%	70%	130%	NA	70%	130%
Beryllium	9397199	9397199	<2	<2	NA	< 2	112%	70%	130%	111%	70%	130%	NA	70%	130%
Bismuth	9397199	9397199	<5	<5	NA	< 5	101%	70%	130%	NA	130%	130%	NA	70%	130%
Boron	9397199	9397199	<2	<2	NA	< 2	103%	70%	130%	107%	70%	130%	NA	70%	130%
Cadmium	9397199	9397199	1.0	1.0	NA	< 0.3	96%	70%	130%	96%	70%	130%	NA	70%	130%
Chromium	9397199	9397199	<2	<2	NA	< 2	98%	70%	130%	94%	70%	130%	NA	70%	130%
Cobalt	9397199	9397199	<1	<1	NA	< 1	97%	70%	130%	94%	70%	130%	NA	70%	130%
Copper	9397199	9397199	11	12	5.8%	< 2	98%	70%	130%	95%	70%	130%	NA	70%	130%
Iron	9397199	9397199	<50	<50	NA	< 50	90%	70%	130%	88%	70%	130%	NA	70%	130%
Lead	9397199	9397199	<0.4	<0.4	NA	< 0.4	104%	70%	130%	108%	70%	130%	NA	70%	130%
Manganese	9397199	9397199	5	5	NA	< 2	107%	70%	130%	109%	70%	130%	NA	70%	130%
Molybdenum	9397199	9397199	<2	<2	NA	< 2	94%	90%	110%	97%	90%	110%	NA	70%	130%
Nickel	9397199	9397199	<2	<2	NA	< 2	98%	70%	130%	96%	70%	130%	NA	70%	130%
Selenium	9397199	9397199	1	1	NA	< 1	90%	70%	130%	96%	70%	130%	NA	70%	130%
Silver	9397199	9397199	<0.5	<0.5	NA	< 0.5	100%	70%	130%	96%	70%	130%	NA	70%	130%
Strontium	9397199	9397199	38	38	2.1%	< 5	102%	70%	130%	104%	70%	130%	NA	70%	130%
Thallium	9397199	9397199	<0.1	<0.1	NA	< 0.1	96%	70%	130%	98%	70%	130%	NA	70%	130%
Tin	9397199	9397199	<2	<2	NA	< 2	96%	70%	130%	96%	70%	130%	NA	70%	130%
Uranium	9397199	9397199	<0.1	<0.1	NA	< 0.1	98%	70%	130%	101%	70%	130%	NA	70%	130%
Vanadium	9397199	9397199	<2	<2	NA	< 2	97%	70%	130%	93%	70%	130%	NA	70%	130%
Zinc	9397199	9397199	39	40	0.9%	< 5	97%	70%	130%	95%	70%	130%	NA	70%	130%

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Quality Assurance

CLIENT NAME: NOVA SCOTIA LANDS INC
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 18X361280
ATTENTION TO: Tony Walker
SAMPLED BY:

Ultra Trace Analysis

RPT Date: Aug 01, 2018			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Dioxins and Furans (Tissue, WHO 2005)															
2,3,7,8-Tetra CDD	1	9397224	< 0.4	< 0.3	NA	< 0.1	93%	40%	130%	NA	40%	130%	83%	40%	130%
1,2,3,7,8-Penta CDD	1	9397224	< 0.5	< 0.7	NA	< 0.2	89%	40%	130%	NA	40%	130%	98%	40%	130%
1,2,3,4,7,8-Hexa CDD	1	9397224	< 0.7	< 0.8	NA	< 0.2	93%	40%	130%	NA	40%	130%	94%	40%	130%
1,2,3,6,7,8-Hexa CDD	1	9397224	< 0.6	< 0.8	NA	< 0.1	96%	40%	130%	NA	40%	130%	99%	40%	130%
1,2,3,7,8,9-Hexa CDD	1	9397224	< 0.7	< 0.7	NA	< 0.1	94%	40%	130%	NA	40%	130%	100%	40%	130%
1,2,3,4,6,7,8-Hepta CDD	1	9397224	< 1	< 1	NA	< 0.6	92%	40%	130%	NA	40%	130%	91%	40%	130%
Octa CDD	1	9397224	< 2	< 2	NA	< 0.4	92%	40%	130%	NA	40%	130%	90%	40%	130%
2,3,7,8-Tetra CDF	1	9397224	< 0.6	< 0.5	NA	< 0.1	99%	40%	130%	NA	40%	130%	99%	40%	130%
1,2,3,7,8-Penta CDF	1	9397224	< 0.9	< 1	NA	< 0.2	103%	40%	130%	NA	40%	130%	104%	40%	130%
2,3,4,7,8-Penta CDF	1	9397224	0.9	< 0.6	NA	< 0.1	109%	40%	130%	NA	40%	130%	108%	40%	130%
1,2,3,4,7,8-Hexa CDF	1	9397224	< 0.5	< 0.7	NA	< 0.2	103%	40%	130%	NA	40%	130%	108%	40%	130%
1,2,3,6,7,8-Hexa CDF	1	9397224	< 0.6	< 0.6	NA	< 0.2	96%	40%	130%	NA	40%	130%	104%	40%	130%
2,3,4,6,7,8-Hexa CDF	1	9397224	< 0.6	< 0.6	NA	< 0.2	106%	40%	130%	NA	40%	130%	105%	40%	130%
1,2,3,7,8,9-Hexa CDF	1	9397224	< 0.8	< 0.9	NA	< 0.2	94%	40%	130%	NA	40%	130%	103%	40%	130%
1,2,3,4,6,7,8-Hepta CDF	1	9397224	< 1	< 2	NA	< 0.2	102%	40%	130%	NA	40%	130%	106%	40%	130%
1,2,3,4,7,8,9-Hepta CDF	1	9397224	< 2	< 3	NA	< 0.2	95%	40%	130%	NA	40%	130%	104%	40%	130%
Octa CDF	1	9397224	< 2	< 3	NA	< 0.3	85%	40%	130%	NA	40%	130%	91%	40%	130%
Dioxins and Furans (Tissue, WHO 2005)															
2,3,7,8-Tetra CDD	1	9397198	< 0.2	< 0.2	NA	< 0.2	87%	40%	130%	NA	40%	130%	89%	40%	130%
1,2,3,7,8-Penta CDD	1	9397198	< 0.4	< 0.4	NA	< 0.4	100%	40%	130%	NA	40%	130%	98%	40%	130%
1,2,3,4,7,8-Hexa CDD	1	9397198	< 0.3	< 0.2	NA	< 0.2	96%	40%	130%	NA	40%	130%	103%	40%	130%
1,2,3,6,7,8-Hexa CDD	1	9397198	< 0.2	< 0.2	NA	< 0.2	107%	40%	130%	NA	40%	130%	100%	40%	130%
1,2,3,7,8,9-Hexa CDD	1	9397198	< 0.2	< 0.2	NA	< 0.2	109%	40%	130%	NA	40%	130%	112%	40%	130%
1,2,3,4,6,7,8-Hepta CDD	1	9397198	< 0.5	< 0.5	NA	< 0.5	104%	40%	130%	NA	40%	130%	99%	40%	130%
Octa CDD	1	9397198	1	1	0.0%	< 0.3	104%	40%	130%	NA	40%	130%	95%	40%	130%
2,3,7,8-Tetra CDF	1	9397198	0.5	0.5	0.0%	< 0.3	106%	40%	130%	NA	40%	130%	102%	40%	130%
1,2,3,7,8-Penta CDF	1	9397198	< 0.4	< 0.4	NA	< 0.2	110%	40%	130%	NA	40%	130%	105%	40%	130%
2,3,4,7,8-Penta CDF	1	9397198	< 0.3	< 0.4	NA	< 0.2	118%	40%	130%	NA	40%	130%	114%	40%	130%
1,2,3,4,7,8-Hexa CDF	1	9397198	< 0.4	< 0.4	NA	< 0.3	110%	40%	130%	NA	40%	130%	110%	40%	130%
1,2,3,6,7,8-Hexa CDF	1	9397198	< 0.4	< 0.4	NA	< 0.2	106%	40%	130%	NA	40%	130%	116%	40%	130%
2,3,4,6,7,8-Hexa CDF	1	9397198	< 0.4	< 0.4	NA	< 0.2	110%	40%	130%	NA	40%	130%	114%	40%	130%
1,2,3,7,8,9-Hexa CDF	1	9397198	< 0.6	< 0.6	NA	< 0.3	105%	40%	130%	NA	40%	130%	110%	40%	130%
1,2,3,4,6,7,8-Hepta CDF	1	9397198	< 0.4	< 0.4	NA	< 0.4	108%	40%	130%	NA	40%	130%	108%	40%	130%
1,2,3,4,7,8,9-Hepta CDF	1	9397198	< 0.6	< 0.6	NA	< 0.6	110%	40%	130%	NA	40%	130%	115%	40%	130%
Octa CDF	1	9397198	< 0.6	< 0.4	NA	< 0.4	105%	40%	130%	NA	40%	130%	101%	40%	130%

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Quality Assurance

CLIENT NAME: NOVA SCOTIA LANDS INC
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 18X361280
ATTENTION TO: Tony Walker
SAMPLED BY:

Ultra Trace Analysis (Continued)

RPT Date: Aug 01, 2018			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper

Methyl Mercury Results

Flett Research Ltd.
440 DeSalaberry Ave. Winnipeg, MB R2L 0Y7
Fax/Phone (204) 667-2505
E-mail: flett@flettresearch.ca Webpage: http://www.flettresearch.ca

CLIENT: AGAT Labs - Dartmouth: 18x361280
Unit 122-11 Morris Drive
Dartmouth, NS B3B 1M2

Matrix: Tissue (wet)
Transaction ID: 718
PO/Contract No.:
Date Received: July 24, 2018
Sampling Date: July 11, 2018
Date Analysed: July 27, 2018
Analyst(s): Xiang W.

Analytical Method: M10220: Methyl Mercury in Tissue by Digestion, Aqueous Ethylation, Purge & Trap, and CVAFS with an Automated System (Version 3)

Comments: Samples are wet tissues which were homogenized at AGAT.

Detection Limit: 4 ng/g (ML) MDL = 1 ng/g The MDL was determined based on 7 replicates of analytical blanks (98% confidence level) and a 100 mg wet sample size.
For reporting purposes results will be flagged below the ML which is considered a practical quantitation limit.

Estimated Uncertainty: The estimated uncertainty of this method has been determined to be ± 13% at a concentration level of 4470 ng/g (95% confidence)

Results authorized by Dr. Robert J. Flett, Chief Scientist

QUALITY DATA

Blanks		pg of MeHg in whole ethylation EPA vial	Gross Peak Area	Mean Ethylation Blank (ng/L)
	Ethylation blank (H_2O+Reagen	0.42	1422	0.01
	Mean Eth. Blank (last 30 runs)	0.30		0.01
		Net pg MeHg in whole Ethylation EPA vial	Gross Peak Area	Equiv. CH Hg Conc. - based on current batch mean weight (0.0971g) of wet sample, ng/g (Biota)
	Method Blank 1	-0.30	387	-0.273
	Method Blank 2	-0.29	437	-0.244
	Method Blank 3	0.01	1448	0.007
	Mean Method Blank	-0.20		-0.170
Standards		MeHg Standard Added to Ethylation EPA Vial (pg CH_3Hg)	Gross Peak Area	Net Corrected MeHg Std Calibration Factor (units / pg)
	Mean Value			5788

Spike Recovery (Matrix Spike (MS) and Matrix Spike Duplicate (MSD))	Sample Identification	Sample Type	Gross Peak Area	% CH_3Hg Recovery Used for Calculations	Wet Sample Mass (g)	Net CH_3Hg as Hg (ng/g-Wet-Wt)	CH_3Hg Recovery (%)
	Mean of Recoveries of July 27, 2018						91.1
QC Samples	Dorm-4 ID1501 (355± 28 ng/g)		321860	100%	0.025		95.3
	Dorm-4 ID1501 (355± 28 ng/g)	Repeat Aliquot	313604	100%	0.025		92.9
	Mean of Dorm-4						94.1
Alternate Source Standard (A.S.S.)	A.S.S. - Alfa ID1302 (1000 ng/L)		186408	100%		< Net CH_3Hg as Hg (ng/L)	108.7

LAB ID	Sampling Details	Sample ID	Date Sampled	Sample Type	Gross Peak Area	% CH_3Hg Recovery Used for Calculations	Weighed Wet Sample Mass (g)	Net CH3Hg as Hg (ng/g) Wet Wt. [recovery corrected]
89003	9397168C	CNE1	July 11, 2018		117577	91.1	0.0564	57.5
89004	9397168C	CNE2	July 11, 2018		53171	91.1	0.0613	24.0
89005	9397180C	CNE8	July 11, 2018		273254	91.1	0.2338	32.6
89006	9397188C	C N8	July 11, 2018		72788	91.1	0.0745	27.0
89007	9397198C	C N3	July 11, 2018		124832	91.1	0.0874	39.5
89008	9397199C	C N2	July 11, 2018		63666	91.1	0.0690	25.7

* : See 'Comments' section above for discussion.

Q:\Clients A-L\AGAT Labs - Dartmouth\2018\718\Methyl Mercury\MTRC70727 MOW1.xls

This test report shall not be reproduced, except in full, without written approval of the laboratory.
Note: Results relate only to the items tested.

CALA
Testing Accreditation No. A 3306

M10080-1 Version 09/17

AGAT Laboratories

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: NOVA SCOTIA LANDS INC
PO BOX 430, STATION A
SYDNEY , NS B1P6H2
(902) 564-7933

ATTENTION TO: Tony Walker

PROJECT: Mussel

AGAT WORK ORDER: 18X361338

MISCELLANEOUS ANALYSIS REVIEWED BY: Kelly Hogue, B.Sc, P.Chem, Operations Manager

SOIL ANALYSIS REVIEWED BY: Laura Baker, Inorganics Data Reporter

ULTRA TRACE REVIEWED BY: Philippe Morneau, chimiste

DATE REPORTED: Aug 01, 2018

PAGES (INCLUDING COVER): 17

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (902) 468-8718

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

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Certificate of Analysis

AGAT WORK ORDER: 18X361338
PROJECT: Mussel

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http://www.agatlabs.com

CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Subcontracted Data Received

DATE RECEIVED: 2018-07-12 **DATE REPORTED:** 2018-08-01

			SAMPLE DESCRIPTION:	M3	M4	M8
			SAMPLE TYPE:	Tissue	Tissue	Tissue
			DATE SAMPLED:	2018-07-10	2018-07-10	2018-07-10
Parameter	Unit	G / S	RDL	8387661	8387667	8387681
Subcontracted Data				Y	Y	Y

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 18X361338

PROJECT: Mussel

11 Morris Drive, Unit 122
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CLIENT NAME: NOVA SCOTIA LANDS INC

SAMPLING SITE:

ATTENTION TO: Tony Walker

SAMPLED BY:

Mercury Analysis in Tissue

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-08-01

Parameter	Unit	G / S	RDL	M1	M2	M3	M4	M5	M6	M7	M8
SAMPLE TYPE:				Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
DATE SAMPLED:				2018-07-10	2018-07-10	2018-07-10	2018-07-10	2018-07-10	2018-07-10	2018-07-10	2018-07-10
				8387650	8387660	8387661	8387667	8387674	8387679	8387680	8387681
Mercury in Tissue	mg/kg		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

8387650-8387681 Results are based on the wet weight of the sample.

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 18X361338

PROJECT: Mussel

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
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http://www.agatlabs.com

CLIENT NAME: NOVA SCOTIA LANDS INC

SAMPLING SITE:

ATTENTION TO: Tony Walker

SAMPLED BY:

Metals in Tissue

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-08-01

Parameter	Unit	G / S	RDL	M1	M2	M3	M4	M5	M6	M7	M8
SAMPLE TYPE:				Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
DATE SAMPLED:				2018-07-10	2018-07-10	2018-07-10	2018-07-10	2018-07-10	2018-07-10	2018-07-10	2018-07-10
				8387650	8387660	8387661	8387667	8387674	8387679	8387680	8387681
Aluminum	mg/kg		10	24	31	36	26	23	<10	20	30
Antimony	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Arsenic	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Barium	mg/kg		5	<5	<5	<5	<5	<5	<5	<5	<5
Beryllium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Bismuth	mg/kg		5	<5	<5	<5	<5	<5	<5	<5	<5
Boron	mg/kg		2	3	3	4	3	4	4	4	3
Cadmium	mg/kg		0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.3	<0.3	<0.3
Chromium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Cobalt	mg/kg		1	<1	<1	<1	<1	<1	<1	<1	<1
Copper	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	2
Iron	mg/kg		50	67	96	85	89	60	<50	67	77
Lead	mg/kg		0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Manganese	mg/kg		2	16	19	13	11	17	4	9	12
Molybdenum	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Nickel	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Selenium	mg/kg		1	<1	<1	<1	<1	<1	<1	<1	<1
Silver	mg/kg		0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Strontium	mg/kg		5	8	11	21	8	13	7	19	6
Thallium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Uranium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Zinc	mg/kg		5	17	9	13	11	13	7	15	20

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

8387650-8387681 Results are based on the wet weight of the sample.

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 18X361338

PROJECT: Mussel

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http://www.agatlabs.com

CLIENT NAME: NOVA SCOTIA LANDS INC

SAMPLING SITE:

ATTENTION TO: Tony Walker

SAMPLED BY:

Tissue Prep

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-08-01

Parameter	Unit	G / S	RDL	M1	M2	M3	M4	M5	M6	M7	M8
SAMPLE TYPE:				Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
DATE SAMPLED:				2018-07-10	2018-07-10	2018-07-10	2018-07-10	2018-07-10	2018-07-10	2018-07-10	2018-07-10
				8387650	8387660	8387661	8387667	8387674	8387679	8387680	8387681
Prep Complete				Y	Y	Y	Y	Y	Y	Y	Y

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Certificate of Analysis

AGAT WORK ORDER: 18X361338
PROJECT: Mussel

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CLIENT NAME: NOVA SCOTIA LANDS INC
ATTENTION TO: Tony Walker
SAMPLING SITE:
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 **DATE REPORTED: 2018-08-01**

			SAMPLE DESCRIPTION:	M1		M2		M3		M4
			SAMPLE TYPE:	Tissue		Tissue		Tissue		Tissue
			DATE SAMPLED:	2018-07-10		2018-07-10		2018-07-10		2018-07-10
Parameter	Unit	G / S	RDL	9387650	RDL	9387660	RDL	9387661	RDL	9387667
2,3,7,8-Tetra CDD	ng/kg		0.2	<0.2	0.2	<0.2	0.2	<0.2	0.2	<0.2
1,2,3,7,8-Penta CDD	ng/kg		0.4	<0.4	0.4	<0.4	0.4	<0.4	0.4	<0.4
1,2,3,4,7,8-Hexa CDD	ng/kg		0.4	<0.4	0.6	<0.6	0.3	<0.3	0.2	<0.2
1,2,3,6,7,8-Hexa CDD	ng/kg		0.3	<0.3	0.5	<0.5	0.3	<0.3	0.2	<0.2
1,2,3,7,8,9-Hexa CDD	ng/kg		0.3	<0.3	0.6	<0.6	0.3	<0.3	0.2	<0.2
1,2,3,4,6,7,8-Hepta CDD	ng/kg		0.5	0.5	0.7	0.8	0.5	<0.5	0.5	0.9
Octa CDD	ng/kg		2	5	2	6	1	1	0.7	<0.7
2,3,7,8-Tetra CDF	ng/kg		0.3	0.3	0.3	0.3	0.3	<0.3	0.3	<0.3
1,2,3,7,8-Penta CDF	ng/kg		0.3	<0.3	0.4	<0.4	0.2	<0.2	0.2	<0.2
2,3,4,7,8-Penta CDF	ng/kg		0.2	<0.2	0.3	<0.3	0.2	<0.2	0.2	<0.2
1,2,3,4,7,8-Hexa CDF	ng/kg		0.3	<0.3	0.3	<0.3	0.3	<0.3	0.3	<0.3
1,2,3,6,7,8-Hexa CDF	ng/kg		0.3	<0.3	0.3	<0.3	0.2	<0.2	0.2	<0.2
2,3,4,6,7,8-Hexa CDF	ng/kg		0.3	<0.3	0.3	<0.3	0.3	<0.3	0.2	<0.2
1,2,3,7,8,9-Hexa CDF	ng/kg		0.4	<0.4	0.4	<0.4	0.4	<0.4	0.3	<0.3
1,2,3,4,6,7,8-Hepta CDF	ng/kg		0.4	<0.4	0.4	<0.4	0.4	<0.4	0.4	<0.4
1,2,3,4,7,8,9-Hepta CDF	ng/kg		0.6	<0.6	0.6	<0.6	0.6	<0.6	0.6	<0.6
Octa CDF	ng/kg		0.8	<0.8	0.5	<0.5	0.9	<0.9	2	<2
Total Tetrachlorodibenzodioxins	ng/kg		0.2	0.5	0.2	0.7	0.2	0.3	0.2	0.6
Total Pentachlorodibenzodioxins	ng/kg		0.4	<0.4	0.4	0.9	0.4	0.4	0.4	0.5
Total Hexachlorodibenzodioxins	ng/kg		0.4	<0.4	0.6	1.0	0.3	1.0	0.2	0.5
Total Heptachlorodibenzodioxins	ng/kg		0.5	4.1	0.7	3.3	0.5	1.4	0.5	0.8
Total PCDDs	ng/kg		2	10	2	12	1	4	0.7	2.7
Total Tetrachlorodibenzofurans	ng/kg		0.3	2.1	0.3	1.1	0.3	0.7	0.3	0.7
Total Pentachlorodibenzofurans	ng/kg		0.3	1.0	0.4	1.4	0.2	0.9	0.2	0.2
Total Hexachlorodibenzofurans	ng/kg		0.4	0.7	0.4	0.5	0.4	0.5	0.3	0.3
Total Heptachlorodibenzofurans	ng/kg		0.6	0.7	0.6	1.3	0.6	0.7	0.6	<0.6
Total PCDFs	ng/kg		0.8	4.5	0.6	4.4	0.9	2.9	2	<2
2,3,7,8-Tetra CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,7,8-Penta CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0

Certificate of Analysis

AGAT WORK ORDER: 18X361338
PROJECT: Mussel

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CLIENT NAME: NOVA SCOTIA LANDS INC
ATTENTION TO: Tony Walker
SAMPLING SITE:
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12 **DATE REPORTED: 2018-08-01**

			SAMPLE DESCRIPTION:	M1		M2		M3		M4
			SAMPLE TYPE:	Tissue		Tissue		Tissue		Tissue
			DATE SAMPLED:	2018-07-10		2018-07-10		2018-07-10		2018-07-10
Parameter	Unit	G / S	RDL	9387650	RDL	9387660	RDL	9387661	RDL	9387667
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	TEQ			0.00546		0.00842		0		0.00885
Octa CDD (TEF 0.0003)	TEQ			0.00138		0.00183		0.000365		0
2,3,7,8-Tetra CDF (TEF 0.1)	TEQ			0.0281		0.0274		0		0
1,2,3,7,8-Penta CDF (TEF 0.03)	TEQ			0		0		0		0
2,3,4,7,8-Penta CDF (TEF 0.3)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
Octa CDF (TEF 0.0003)	TEQ			0		0		0		0
Total PCDDs and PCDFs (TEQ)	TEQ			0.0349		0.0377		0.000365		0.00885

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Certificate of Analysis

AGAT WORK ORDER: 18X361338
PROJECT: Mussel

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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-08-01

		SAMPLE DESCRIPTION:	M1	M2	M3	M4
		SAMPLE TYPE:	Tissue	Tissue	Tissue	Tissue
		DATE SAMPLED:	2018-07-10	2018-07-10	2018-07-10	2018-07-10
Surrogate	Unit	Acceptable Limits	8387650	8387660	8387661	8387667
13C-2378-TCDF	%	30-140	61	65	64	59
13C-12378-PeCDF	%	30-140	55	62	59	54
13C-23478-PeCDF	%	30-140	63	72	69	62
13C-123478-HxCDF	%	30-140	63	60	58	59
13C-123678-HxCDF	%	30-140	70	63	65	64
13C-234678-HxCDF	%	30-140	72	61	64	65
13C-123789-HxCDF	%	30-140	68	64	60	61
13C-1234678-HpCDF	%	30-140	60	57	54	53
13C-1234789-HpCDF	%	30-140	57	55	49	51
13C-2378-TCDD	%	30-140	77	80	77	76
13C-12378-PeCDD	%	30-140	70	78	76	68
13C-123478-HxCDD	%	30-140	75	66	67	66
13C-123678-HxCDD	%	30-140	83	76	76	77
13C-1234678-HpCDD	%	30-140	64	60	54	56
13C-OCDD	%	30-140	34	33	32	34

AGAT Laboratories

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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-08-01

		SAMPLE DESCRIPTION:		M5		M6		M7		M8
		SAMPLE TYPE:		Tissue		Tissue		Tissue		Tissue
		DATE SAMPLED:		2018-07-10		2018-07-10		2018-07-10		2018-07-10
Parameter	Unit	G / S	RDL	8387674	RDL	8387679	RDL	8387680	RDL	8387681
2,3,7,8-Tetra CDD	ng/kg		0.2	<0.2	0.2	<0.2	0.2	<0.2	0.2	<0.2
1,2,3,7,8-Penta CDD	ng/kg		0.4	<0.4	0.4	<0.4	0.4	<0.4	0.4	<0.4
1,2,3,4,7,8-Hexa CDD	ng/kg		0.2	<0.2	0.2	<0.2	0.4	<0.4	0.6	<0.6
1,2,3,6,7,8-Hexa CDD	ng/kg		0.2	<0.2	0.2	<0.2	0.3	<0.3	0.5	<0.5
1,2,3,7,8,9-Hexa CDD	ng/kg		0.2	<0.2	0.2	<0.2	0.4	<0.4	0.6	<0.6
1,2,3,4,6,7,8-Hepta CDD	ng/kg		0.5	<0.5	0.6	<0.6	0.7	<0.7	1	2
Octa CDD	ng/kg		1	2.7	1	<1	0.9	<0.9	4	7
2,3,7,8-Tetra CDF	ng/kg		0.3	0.3	0.3	<0.3	0.3	0.4	0.4	0.4
1,2,3,7,8-Penta CDF	ng/kg		0.2	<0.2	0.2	<0.2	0.2	<0.2	0.4	<0.4
2,3,4,7,8-Penta CDF	ng/kg		0.2	<0.2	0.2	<0.2	0.2	<0.2	0.4	<0.4
1,2,3,4,7,8-Hexa CDF	ng/kg		0.3	<0.3	0.3	<0.3	0.3	<0.3	0.3	<0.3
1,2,3,6,7,8-Hexa CDF	ng/kg		0.2	<0.2	0.2	<0.2	0.2	<0.2	0.3	<0.3
2,3,4,6,7,8-Hexa CDF	ng/kg		0.2	<0.2	0.2	<0.2	0.2	<0.2	0.5	<0.5
1,2,3,7,8,9-Hexa CDF	ng/kg		0.3	<0.3	0.3	<0.3	0.3	<0.3	0.7	<0.7
1,2,3,4,6,7,8-Hepta CDF	ng/kg		0.4	<0.4	0.4	<0.4	0.5	<0.5	0.6	<0.6
1,2,3,4,7,8,9-Hepta CDF	ng/kg		0.6	<0.6	0.6	<0.6	0.8	<0.8	1	<1
Octa CDF	ng/kg		0.7	<0.7	1	<1	1	<1	1	<1
Total Tetrachlorodibenzodioxins	ng/kg		0.2	0.3	0.2	<0.2	0.2	1.7	0.2	1.5
Total Pentachlorodibenzodioxins	ng/kg		0.4	0.6	0.4	0.5	0.4	1.4	0.4	3.8
Total Hexachlorodibenzodioxins	ng/kg		0.2	0.8	0.2	0.3	0.4	2.6	0.6	1.4
Total Heptachlorodibenzodioxins	ng/kg		0.5	1.2	0.6	<0.6	0.7	1.5	1	6
Total PCDDs	ng/kg		1	6	1	<1	0.9	7.1	4	19
Total Tetrachlorodibenzofurans	ng/kg		0.3	0.6	0.3	0.5	0.3	1.3	0.4	2.9
Total Pentachlorodibenzofurans	ng/kg		0.2	0.7	0.2	<0.2	0.2	0.8	0.4	4.7
Total Hexachlorodibenzofurans	ng/kg		0.3	0.3	0.3	<0.3	0.3	0.5	0.7	1.1
Total Heptachlorodibenzofurans	ng/kg		0.6	<0.6	0.6	<0.6	0.8	<0.8	1	<1
Total PCDFs	ng/kg		0.7	1.8	1	1	1	3	1	9
2,3,7,8-Tetra CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,7,8-Penta CDD (TEF 1.0)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0

Certificate of Analysis

AGAT WORK ORDER: 18X361338
PROJECT: Mussel

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Dartmouth, Nova Scotia
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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-08-01

Parameter	Unit	G / S	RDL	M5 Tissue 2018-07-10 9387674	RDL	M6 Tissue 2018-07-10 9387679	RDL	M7 Tissue 2018-07-10 9387680	RDL	M8 Tissue 2018-07-10 9387681
1,2,3,6,7,8-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDD (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDD (TEF 0.01)	TEQ			0		0		0		0.0138
Octa CDD (TEF 0.0003)	TEQ			0.000798		0		0		0.00210
2,3,7,8-Tetra CDF (TEF 0.1)	TEQ			0.0292		0		0.0358		0.0365
1,2,3,7,8-Penta CDF (TEF 0.03)	TEQ			0		0		0		0
2,3,4,7,8-Penta CDF (TEF 0.3)	TEQ			0		0		0		0
1,2,3,4,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
2,3,4,6,7,8-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,7,8,9-Hexa CDF (TEF 0.1)	TEQ			0		0		0		0
1,2,3,4,6,7,8-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
1,2,3,4,7,8,9-Hepta CDF (TEF 0.01)	TEQ			0		0		0		0
Octa CDF (TEF 0.0003)	TEQ			0		0		0		0
Total PCDDs and PCDFs (TEQ)	TEQ			0.0300		0		0.0358		0.0555

Certificate of Analysis

AGAT WORK ORDER: 18X361338
PROJECT: Mussel

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
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CLIENT NAME: NOVA SCOTIA LANDS INC
SAMPLING SITE:

ATTENTION TO: Tony Walker
SAMPLED BY:

Dioxins and Furans (Tissue, WHO 2005)

DATE RECEIVED: 2018-07-12

DATE REPORTED: 2018-08-01

Surrogate	Unit	Acceptable Limits	M5 Tissue 2018-07-10 9387674	M6 Tissue 2018-07-10 9387679	M7 Tissue 2018-07-10 9387680	M8 Tissue 2018-07-10 9387681
13C-2378-TCDF	%	30-140	56	36	50	38
13C-12378-PeCDF	%	30-140	53	44	41	116
13C-23478-PeCDF	%	30-140	57	47	46	66
13C-123478-HxCDF	%	30-140	62	62	72	62
13C-123678-HxCDF	%	30-140	74	88	104	80
13C-234678-HxCDF	%	30-140	73	89	95	70
13C-123789-HxCDF	%	30-140	69	64	71	59
13C-1234678-HpCDF	%	30-140	52	58	63	62
13C-1234789-HpCDF	%	30-140	50	44	59	52
13C-2378-TCDD	%	30-140	75	82	62	94
13C-12378-PeCDD	%	30-140	64	73	48	112
13C-123478-HxCDD	%	30-140	70	72	82	59
13C-123678-HxCDD	%	30-140	82	113	123	92
13C-1234678-HpCDD	%	30-140	54	61	64	59
13C-OCDD	%	30-140	31	34	32	32

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9387650-9387681 The results were corrected based on the surrogate percent recoveries.

AGAT Laboratories

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Quality Assurance

CLIENT NAME: NOVA SCOTIA LANDS INC | **AGAT WORK ORDER: 18X361338**
PROJECT: Mussel | **ATTENTION TO: Tony Walker**
SAMPLING SITE: | **SAMPLED BY:**

Soil Analysis

RPT Date: Aug 01, 2018			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Metals in Tissue															
Aluminum	9397881	9397881	30	37	NA	< 10	98%	70%	130%	102%	70%	130%	NA	70%	130%
Antimony	9397881	9397881	<2	<2	NA	< 2	91%	70%	130%	101%	70%	130%	NA	70%	130%
Arsenic	9397881	9397881	<2	<2	NA	< 2	98%	70%	130%	101%	70%	130%	NA	70%	130%
Barium	9397881	9397881	<5	<5	NA	< 5	95%	70%	130%	98%	70%	130%	NA	70%	130%
Beryllium	9397881	9397881	<2	<2	NA	< 2	104%	70%	130%	107%	70%	130%	NA	70%	130%
Bismuth	9397881	9397881	<5	<5	NA	< 5	104%	70%	130%	NA	130%	130%	NA	70%	130%
Boron	9397881	9397881	3	4	NA	< 2	105%	70%	130%	106%	70%	130%	NA	70%	130%
Cadmium	9397881	9397881	<0.3	<0.3	NA	< 0.3	97%	70%	130%	99%	70%	130%	NA	70%	130%
Chromium	9397881	9397881	<2	<2	NA	< 2	107%	70%	130%	107%	70%	130%	NA	70%	130%
Cobalt	9397881	9397881	<1	<1	NA	< 1	106%	70%	130%	107%	70%	130%	NA	70%	130%
Copper	9397881	9397881	2	2	NA	< 2	106%	70%	130%	110%	70%	130%	NA	70%	130%
Iron	9397881	9397881	77	103	NA	< 50	103%	70%	130%	114%	70%	130%	NA	70%	130%
Lead	9397881	9397881	<0.4	0.4	NA	< 0.4	104%	70%	130%	106%	70%	130%	NA	70%	130%
Manganese	9397881	9397881	12	13	9.1%	< 2	113%	70%	130%	114%	70%	130%	NA	70%	130%
Molybdenum	9397881	9397881	<2	<2	NA	< 2	98%	90%	110%	102%	90%	110%	NA	70%	130%
Nickel	9397881	9397881	<2	<2	NA	< 2	105%	70%	130%	108%	70%	130%	NA	70%	130%
Selenium	9397881	9397881	<1	<1	NA	< 1	97%	70%	130%	98%	70%	130%	NA	70%	130%
Silver	9397881	9397881	<0.5	<0.5	NA	< 0.5	106%	70%	130%	110%	70%	130%	NA	70%	130%
Strontium	9397881	9397881	6	7	NA	< 5	102%	70%	130%	106%	70%	130%	NA	70%	130%
Thallium	9397881	9397881	<0.1	<0.1	NA	< 0.1	103%	70%	130%	105%	70%	130%	NA	70%	130%
Tin	9397881	9397881	<2	<2	NA	< 2	96%	70%	130%	97%	70%	130%	NA	70%	130%
Uranium	9397881	9397881	<0.1	<0.1	NA	< 0.1	101%	70%	130%	102%	70%	130%	NA	70%	130%
Vanadium	9397881	9397881	<2	<2	NA	< 2	105%	70%	130%	106%	70%	130%	NA	70%	130%
Zinc	9397881	9397881	20	19	NA	< 5	102%	70%	130%	104%	70%	130%	NA	70%	130%
Mercury Analysis in Tissue															
Mercury in Tissue	1	9403978	0.05	0.05	NA	< 0.05	NA	70%	130%	NA	70%	130%	89%	70%	130%

AGAT Laboratories

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Quality Assurance

CLIENT NAME: NOVA SCOTIA LANDS INC | AGAT WORK ORDER: 18X361338

PROJECT: Mussel | ATTENTION TO: Tony Walker

SAMPLING SITE: | SAMPLED BY:

Ultra Trace Analysis

RPT Date: Aug 01, 2018			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Dioxins and Furans (Tissue, WHO 2005)															
2,3,7,8-Tetra CDD	1	9397198	< 0.2	< 0.2	NA	< 0.2	87%	40%	130%	NA	40%	130%	89%	40%	130%
1,2,3,7,8-Penta CDD	1	9397198	< 0.4	< 0.4	NA	< 0.4	100%	40%	130%	NA	40%	130%	98%	40%	130%
1,2,3,4,7,8-Hexa CDD	1	9397198	< 0.3	< 0.2	NA	< 0.2	96%	40%	130%	NA	40%	130%	103%	40%	130%
1,2,3,6,7,8-Hexa CDD	1	9397198	< 0.2	< 0.2	NA	< 0.2	107%	40%	130%	NA	40%	130%	100%	40%	130%
1,2,3,7,8,9-Hexa CDD	1	9397198	< 0.2	< 0.2	NA	< 0.2	109%	40%	130%	NA	40%	130%	112%	40%	130%
1,2,3,4,6,7,8-Hepta CDD	1	9397198	< 0.5	< 0.5	NA	< 0.5	104%	40%	130%	NA	40%	130%	99%	40%	130%
Octa CDD	1	9397198	1	1	0.0%	< 0.3	104%	40%	130%	NA	40%	130%	95%	40%	130%
2,3,7,8-Tetra CDF	1	9397198	0.5	0.5	0.0%	< 0.3	106%	40%	130%	NA	40%	130%	102%	40%	130%
1,2,3,7,8-Penta CDF	1	9397198	< 0.4	< 0.4	NA	< 0.2	110%	40%	130%	NA	40%	130%	105%	40%	130%
2,3,4,7,8-Penta CDF	1	9397198	< 0.3	< 0.4	NA	< 0.2	118%	40%	130%	NA	40%	130%	114%	40%	130%
1,2,3,4,7,8-Hexa CDF	1	9397198	< 0.4	< 0.4	NA	< 0.3	110%	40%	130%	NA	40%	130%	110%	40%	130%
1,2,3,6,7,8-Hexa CDF	1	9397198	< 0.4	< 0.4	NA	< 0.2	106%	40%	130%	NA	40%	130%	116%	40%	130%
2,3,4,6,7,8-Hexa CDF	1	9397198	< 0.4	< 0.4	NA	< 0.2	110%	40%	130%	NA	40%	130%	114%	40%	130%
1,2,3,7,8,9-Hexa CDF	1	9397198	< 0.6	< 0.6	NA	< 0.3	105%	40%	130%	NA	40%	130%	110%	40%	130%
1,2,3,4,6,7,8-Hepta CDF	1	9397198	< 0.4	< 0.4	NA	< 0.4	106%	40%	130%	NA	40%	130%	106%	40%	130%
1,2,3,4,7,8,9-Hepta CDF	1	9397198	< 0.6	< 0.6	NA	< 0.6	110%	40%	130%	NA	40%	130%	115%	40%	130%
Octa CDF	1	9397198	< 0.8	< 0.4	NA	< 0.4	105%	40%	130%	NA	40%	130%	101%	40%	130%

Methyl Mercury Results

Flett Research Ltd.

440 DeSalaberry Ave. Winnipeg, MB R2L 0Y7
[illegible]
E-mail: flett@flettresearch.ca Webpage: http://www.flettresearch.ca

CLIENT: AGAT Labs - Dartmouth: 18x361338

Unit 122-11 Morris Drive
Dartmouth, NS B3B 1M2

Date Received: July 19, 2018
Sampling Date: July 10, 2018

Matrix: Tissue (wet)
Transaction ID: 718
PO/Contract No.:
Date Analysed: July 26, 2018
Analyst(s): Xiang W.

Analytical Method: M10200: Methyl Mercury in Tissue by Digestion, Aqueous Ethylation, Purge & Trap, and CVAFS with an Automated System (Version 2)

Comments: Samples are wet tissues which were homogenized at AGAT.

Detection Limit: 4 ng/g (ML) MDL = 1 ng/g The MDL was determined based on 7 replicates of analytical blanks (99% confidence level) and a 100 mg wet sample size.
For reporting purposes results will be flagged below the ML which is considered a practical quantitation limit.

Estimated Uncertainty: The estimated uncertainty of this method has been determined to be ± 13% at a concentration level of 4470 ng/g (95% confidence)

Results authorized by: Dr. Robert J. Flett, Chief Scientist

QUALITY DATA

Blanks		pg of MeHg in whole ethylation BPA vial	Gross Peak Area	Mean Ethylation Blank (ng/L)
	Ethylation blank (H2O+Reagent)	0.24	776	0.01
	Mean Eth. Blank (last 30 runs)	0.30		0.01
		Net pg MeHg in whole Ethylation BPA vial	Gross Peak Area	Equiv. CH3Hg Conc. based on current batch mean weight (0.1075g) of wet sample, ng/g (Note)
	Method Blank 1	-0.02	700	-0.012
	Method Blank 2	-0.13	454	-0.074
	Method Blank 3	-0.03	653	-0.027
	Mean Method Blank	-0.06		-0.040
Standards		MeHg Standard Added to Ethylation BPA Vial (pg CH3Hg)	Gross Peak Area	Net Corrected MeHg Std Calibration Factor (units / pg)
	Mean Value			5603

Spike Recovery	Sample Identification	Sample Type	Gross Peak Area	% CH3Hg Recovery Used for Calculations	Wet Sample Mass (g)	Net CH3Hg as Hg (ng/g Wet Wt)	CH3Hg Recovery (%)
	0327687 (M4)	MSD	160679	100%	0.089	84	92.1
	0327687 (M4)	MSDD	180320	100%	0.085	79	93.3
	Mean of Recoveries						92.7
QC Samples	Dorm-4 IC001 (MeHg 28 ng/g)		339592	100%	0.025		100.1
	Dorm-4 IC001 (MeHg 28 ng/g)	Repeat Aliquot	339031	100%	0.025		94.6
	Mean of Dorm-4						97.3
[illegible]	A.E.S. - Alfa IC002 (1000 ng/L)		172381	100%		[illegible]	102.9

LAB ID	Sampling Details	Sample ID	Date Sampled	Sample Type	Gross Peak Area	% CH3Hg Recovery Used for Calculations	Weighed Wet Sample Mass (g)	Net CH3Hg as Hg (ng/g) Wet Wt. [recovery corrected]
[illegible]	[illegible]	M3	July 10, 2018		15651	93.7	0.1780	< 3.52
[illegible]	[illegible]	M4	July 10, 2018		8436	93.7	0.1183	< 1.81
[illegible]	[illegible]	M7	July 10, 2018	Dup#1	13049	93.7	0.0575	5.40
[illegible]	[illegible]	M7	July 10, 2018	Dup#2	15676	93.7	0.0781	5.35

* : See 'Comments' section above for discussion.

< : Result below the official detection limit for this analyte in this matrix.

Dup : Duplicate - two subsamples of the same sample carried through the analytical procedure in an identical manner.

O:\Clients A-L\AGAT Labs - Dartmouth\2018\718\Methyl Mercury\[illegible]

This test report shall not be reproduced, except in full, without written approval of the laboratory.
Note: Results relate only to the items tested.

CALA

[illegible]

Your C.O.C. #: 08471354

Attention: Tony Walker

DALHOUSIE UNIVERSITY
WATER RESOURCE STUDIES
PO 15000 (D401)
1360 BARRINGTON ST
HALIFAX, NS
CANADA B3H 4R2

Report Date: 2019/07/31
Report #: R2761156
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

BV LABS JOB #: B948830
Received: 2019/06/20, 09:00

Sample Matrix: Water
Samples Received: 20

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Mercury (Total) by CV	10	2019/07/05	2019/07/10	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Mercury (Total) by CV	10	2019/07/05	2019/07/29	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Elements by ICPMS Digested LL (total)	10	2019/07/05	2019/07/11	BBY7SOP-00003 / BBY7SOP-00002	EPA 6020b R2 m

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in BV Labs profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and BV Labs in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by BV Labs, results relate to the supplied samples tested.
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Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

BV Labs Job #: B948830
Report Date: 2019/07/31

DALHOUSIE UNIVERSITY

MERCURY BY COLD VAPOR (WATER)

BV Labs ID		VY0286	VY0287	VY0288	VY0289	VY0290	VY0291	VY0292		
Sampling Date		2019/06/18 09:35	2019/06/18 09:42	2019/06/18 09:50	2019/06/18 09:52	2019/06/18 09:59	2019/06/18 10:07	2019/06/18 10:15		
COC Number		08471354	08471354	08471354	08471354	08471354	08471354	08471354		
	UNITS	BHM-1	BHM-2	BHM-3	BHM-4	BHM-5	BHM-6	BHM-7	RDL	QC Batch
Elements										
Total Mercury (Hg)	ug/L	<0.020 (1)	<0.020 (1)	<0.020 (1)	<0.020 (1)	<0.020 (1)	<0.020 (1)	<0.020 (1)	0.020	9518064

RDL = Reportable Detection Limit
(1) Detection limit raised based on sample volume used for analysis.

BV Labs ID		VY0293	VY0294	VY0295		VY0296	VY0297	VY0298		
Sampling Date		2019/06/18 10:21	2019/06/18 10:22	2019/06/18 10:36		2019/06/18 09:35	2019/06/18 09:42	2019/06/18 09:50		
COC Number		08471354	08471354	08471354		08471354	08471354	08471354		
	UNITS	BHM-8	BHM-9	BHM-10	QC Batch	BHHG-1	BHHG-2	BHHG-3	RDL	QC Batch
Elements										
Total Mercury (Hg)	ug/L	<0.020 (1)	<0.020 (1)	<0.020 (1)	9518064	<0.020	<0.020	<0.020	0.020	9494808

RDL = Reportable Detection Limit
(1) Detection limit raised based on sample volume used for analysis.

BV Labs ID		VY0299	VY0300	VY0301	VY0302	VY0303	VY0304	VY0305		
Sampling Date		2019/06/18 09:52	2019/06/18 09:59	2019/06/18 10:07	2019/06/18 10:15	2019/06/18 10:21	2019/06/18 10:22	2019/06/18 10:36		
COC Number		08471354	08471354	08471354	08471354	08471354	08471354	08471354		
	UNITS	BHHG-4	BHHG-5	BHHG-6	BHHG-7	BHHG-8	BHHG-9	BHHG-10	RDL	QC Batch
Elements										
Total Mercury (Hg)	ug/L	0.030	<0.020	<0.020	<0.020	0.030	0.025	<0.020	0.020	9494808

RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

BV Labs ID		VY0286	VY0287	VY0288	VY0289	VY0290	VY0291	VY0292		
Sampling Date		2019/06/18 09:35	2019/06/18 09:42	2019/06/18 09:50	2019/06/18 09:52	2019/06/18 09:59	2019/06/18 10:07	2019/06/18 10:15		
COC Number		08471354	08471354	08471354	08471354	08471354	08471354	08471354		
	UNITS	BHM-1	BHM-2	BHM-3	BHM-4	BHM-5	BHM-6	BHM-7	RDL	QC Batch
Total Metals by ICPMS										
Total Aluminum (Al)	ug/L	351	576	528	263	610	568	661	30	9494801
Total Antimony (Sb)	ug/L	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.20	9494801
Total Arsenic (As)	ug/L	1.07	1.60	1.31	1.39	1.35	1.16	1.56	0.20	9494801
Total Barium (Ba)	ug/L	658	1180	711	732	788	602	874	0.50	9494801
Total Beryllium (Be)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	9494801
Total Bismuth (Bi)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	9494801
Total Boron (B)	ug/L	<100	<100	<100	<100	<100	<100	<100	100	9494801
Total Cadmium (Cd)	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	9494801
Total Chromium (Cr)	ug/L	1.4	1.4	1.3	2.0	1.4	1.3	1.2	1.0	9494801
Total Cobalt (Co)	ug/L	0.18	0.27	0.18	0.46	0.31	0.18	0.20	0.10	9494801
Total Copper (Cu)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	9494801
Total Iron (Fe)	ug/L	60	<50	194	96	505	480	458	50	9494801
Total Lead (Pb)	ug/L	0.81	1.05	0.94	1.22	1.11	1.15	1.49	0.20	9494801
Total Lithium (Li)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	9494801
Total Manganese (Mn)	ug/L	10100	10300	8540	12700	9610	6320	9770	1.0	9494801
Total Molybdenum (Mo)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	0.77	1.00	0.50	9494801
Total Nickel (Ni)	ug/L	2.7	2.5	<1.0	2.3	1.0	1.0	1.4	1.0	9494801
Total Phosphorus (P)	ug/L	1820	2190	1360	2250	821	668	761	50	9494801
Total Selenium (Se)	ug/L	0.57	<0.40	<0.40	0.99	<0.40	<0.40	<0.40	0.40	9494801
Total Silicon (Si)	ug/L	<500	909	<500	670	<500	<500	<500	500	9494801
Total Silver (Ag)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	9494801
Total Strontium (Sr)	ug/L	49.5	131	45.4	55.7	44.2	29.0	45.7	0.50	9494801
Total Thallium (Tl)	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.027	0.020	9494801
Total Tin (Sn)	ug/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.0	9494801
Total Titanium (Ti)	ug/L	386	524	433	590	307	286	417	20	9494801
Total Uranium (U)	ug/L	0.102	0.214	0.290	0.087	0.751	0.621	0.766	0.050	9494801
Total Vanadium (V)	ug/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.0	9494801
Total Zinc (Zn)	ug/L	<10	<10	<10	<10	20	19	25	10	9494801
Total Zirconium (Zr)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	9494801
Total Sulphur (S)	ug/L	<6000	<6000	<6000	<6000	<6000	<6000	<6000	6000	9494801
RDL = Reportable Detection Limit										

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

BV Labs ID		VY0293	VY0294	VY0295		
Sampling Date		2019/06/18 10:21	2019/06/18 10:22	2019/06/18 10:36		
COC Number		08471354	08471354	08471354		
	UNITS	BHM-8	BHM-9	BHM-10	RDL	QC Batch
Total Metals by ICPMS						
Total Aluminum (Al)	ug/L	523	402	389	30	9494801
Total Antimony (Sb)	ug/L	<0.20	<0.20	<0.20	0.20	9494801
Total Arsenic (As)	ug/L	1.41	1.33	1.48	0.20	9494801
Total Barium (Ba)	ug/L	846	894	378	0.50	9494801
Total Beryllium (Be)	ug/L	<0.10	<0.10	<0.10	0.10	9494801
Total Bismuth (Bi)	ug/L	<0.10	<0.10	<0.10	0.10	9494801
Total Boron (B)	ug/L	<100	<100	<100	100	9494801
Total Cadmium (Cd)	ug/L	<0.050	<0.050	<0.050	0.050	9494801
Total Chromium (Cr)	ug/L	1.7	1.4	1.3	1.0	9494801
Total Cobalt (Co)	ug/L	0.39	0.20	0.32	0.10	9494801
Total Copper (Cu)	ug/L	1.3	<1.0	<1.0	1.0	9494801
Total Iron (Fe)	ug/L	<50	<50	<50	50	9494801
Total Lead (Pb)	ug/L	0.93	1.07	1.65	0.20	9494801
Total Lithium (Li)	ug/L	<5.0	<5.0	<5.0	5.0	9494801
Total Manganese (Mn)	ug/L	10500	9080	2450	1.0	9494801
Total Molybdenum (Mo)	ug/L	<0.50	0.54	1.63	0.50	9494801
Total Nickel (Ni)	ug/L	2.1	1.4	1.7	1.0	9494801
Total Phosphorus (P)	ug/L	1780	1600	875	50	9494801
Total Selenium (Se)	ug/L	<0.40	0.57	<0.40	0.40	9494801
Total Silicon (Si)	ug/L	797	610	1440	500	9494801
Total Silver (Ag)	ug/L	<0.10	<0.10	<0.10	0.10	9494801
Total Strontium (Sr)	ug/L	85.6	122	169	0.50	9494801
Total Thallium (Tl)	ug/L	<0.020	<0.020	<0.020	0.020	9494801
Total Tin (Sn)	ug/L	<2.0	<2.0	<2.0	2.0	9494801
Total Titanium (Ti)	ug/L	459	461	548	20	9494801
Total Uranium (U)	ug/L	0.196	0.325	0.174	0.050	9494801
Total Vanadium (V)	ug/L	<2.0	<2.0	<2.0	2.0	9494801
Total Zinc (Zn)	ug/L	<10	<10	20	10	9494801
Total Zirconium (Zr)	ug/L	<1.0	<1.0	<1.0	1.0	9494801
Total Sulphur (S)	ug/L	<6000	<6000	<6000	6000	9494801

RDL = Reportable Detection Limit

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
9494801	VCN	Spiked Blank	Total Aluminum (Al)	2019/07/11		102	%	80 - 120
			Total Antimony (Sb)	2019/07/11		95	%	80 - 120
			Total Arsenic (As)	2019/07/11		100	%	80 - 120
			Total Barium (Ba)	2019/07/11		98	%	80 - 120
			Total Beryllium (Be)	2019/07/11		89	%	80 - 120
			Total Bismuth (Bi)	2019/07/11		80	%	80 - 120
			Total Boron (B)	2019/07/11		102	%	80 - 120
			Total Cadmium (Cd)	2019/07/11		93	%	80 - 120
			Total Chromium (Cr)	2019/07/11		91	%	80 - 120
			Total Cobalt (Co)	2019/07/11		87	%	80 - 120
			Total Copper (Cu)	2019/07/11		84	%	80 - 120
			Total Iron (Fe)	2019/07/11		103	%	80 - 120
			Total Lead (Pb)	2019/07/11		92	%	80 - 120
			Total Lithium (Li)	2019/07/11		88	%	80 - 120
			Total Manganese (Mn)	2019/07/11		91	%	80 - 120
			Total Molybdenum (Mo)	2019/07/11		102	%	80 - 120
			Total Nickel (Ni)	2019/07/11		90	%	80 - 120
			Total Selenium (Se)	2019/07/11		100	%	80 - 120
			Total Silver (Ag)	2019/07/11		89	%	80 - 120
			Total Strontium (Sr)	2019/07/11		103	%	80 - 120
			Total Thallium (Tl)	2019/07/11		90	%	80 - 120
			Total Tin (Sn)	2019/07/11		94	%	80 - 120
			Total Titanium (Ti)	2019/07/11		98	%	80 - 120
			Total Uranium (U)	2019/07/11		94	%	80 - 120
			Total Vanadium (V)	2019/07/11		89	%	80 - 120
			Total Zinc (Zn)	2019/07/11		91	%	80 - 120
			Total Zirconium (Zr)	2019/07/11		70 (1)	%	80 - 120
9494801	VCN	RPD	Total Aluminum (Al)	2019/07/11	7.8		%	20
			Total Antimony (Sb)	2019/07/11	96 (1)		%	20
			Total Arsenic (As)	2019/07/11	28 (1)		%	20
			Total Barium (Ba)	2019/07/11	0.62		%	20
			Total Beryllium (Be)	2019/07/11	2.7		%	20
			Total Bismuth (Bi)	2019/07/11	51 (1)		%	20
			Total Boron (B)	2019/07/11	6.0		%	20
			Total Cadmium (Cd)	2019/07/11	1.1		%	20
			Total Chromium (Cr)	2019/07/11	13		%	20
			Total Cobalt (Co)	2019/07/11	6.5		%	20
			Total Copper (Cu)	2019/07/11	11		%	20
			Total Iron (Fe)	2019/07/11	26 (1)		%	20
			Total Lead (Pb)	2019/07/11	4.4		%	20
			Total Lithium (Li)	2019/07/11	4.5		%	20
			Total Manganese (Mn)	2019/07/11	8.6		%	20
			Total Molybdenum (Mo)	2019/07/11	19		%	20
			Total Nickel (Ni)	2019/07/11	5.1		%	20
			Total Selenium (Se)	2019/07/11	27 (1)		%	20
			Total Silver (Ag)	2019/07/11	7.1		%	20
			Total Strontium (Sr)	2019/07/11	10		%	20
			Total Thallium (Tl)	2019/07/11	16		%	20
			Total Tin (Sn)	2019/07/11	25 (1)		%	20
			Total Titanium (Ti)	2019/07/11	21 (1)		%	20
			Total Uranium (U)	2019/07/11	29 (1)		%	20
			Total Vanadium (V)	2019/07/11	12		%	20
			Total Zinc (Zn)	2019/07/11	3.9		%	20
			Total Zirconium (Zr)	2019/07/11	28 (1)		%	20
			Total Aluminum (Al)	2019/07/11	NC		%	20

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Antimony (Sb)	2019/07/11	NC		%	20
			Total Arsenic (As)	2019/07/11	144 (1)		%	20
			Total Barium (Ba)	2019/07/11	74 (1)		%	20
			Total Beryllium (Be)	2019/07/11	NC		%	20
			Total Bismuth (Bi)	2019/07/11	NC		%	20
			Total Boron (B)	2019/07/11	NC		%	20
			Total Cadmium (Cd)	2019/07/11	NC		%	20
			Total Chromium (Cr)	2019/07/11	NC		%	20
			Total Cobalt (Co)	2019/07/11	NC		%	20
			Total Copper (Cu)	2019/07/11	NC		%	20
			Total Iron (Fe)	2019/07/11	NC		%	20
			Total Lead (Pb)	2019/07/11	147 (1)		%	20
			Total Lithium (Li)	2019/07/11	NC		%	20
			Total Manganese (Mn)	2019/07/11	NC		%	20
			Total Molybdenum (Mo)	2019/07/11	NC		%	20
			Total Nickel (Ni)	2019/07/11	NC		%	20
			Total Phosphorus (P)	2019/07/11	NC		%	20
			Total Selenium (Se)	2019/07/11	NC		%	20
			Total Silicon (Si)	2019/07/11	NC		%	20
			Total Silver (Ag)	2019/07/11	NC		%	20
			Total Strontium (Sr)	2019/07/11	157 (1)		%	20
			Total Thallium (Tl)	2019/07/11	NC		%	20
			Total Tin (Sn)	2019/07/11	NC		%	20
			Total Titanium (Ti)	2019/07/11	180 (1)		%	20
			Total Uranium (U)	2019/07/11	NC		%	20
			Total Vanadium (V)	2019/07/11	NC		%	20
			Total Zinc (Zn)	2019/07/11	NC		%	20
			Total Zirconium (Zr)	2019/07/11	NC		%	20
			Total Sulphur (S)	2019/07/11	NC		%	20
9494801	VCN	Method Blank	Total Aluminum (Al)	2019/07/16	<30		ug/L	
			Total Antimony (Sb)	2019/07/16	<0.20		ug/L	
			Total Arsenic (As)	2019/07/16	<0.20		ug/L	
			Total Barium (Ba)	2019/07/16	0.95, RDL=0.50 (2)		ug/L	
			Total Beryllium (Be)	2019/07/16	<0.10		ug/L	
			Total Bismuth (Bi)	2019/07/16	<0.10		ug/L	
			Total Boron (B)	2019/07/16	<100		ug/L	
			Total Cadmium (Cd)	2019/07/16	<0.050		ug/L	
			Total Chromium (Cr)	2019/07/16	<1.0		ug/L	
			Total Cobalt (Co)	2019/07/16	<0.10		ug/L	
			Total Copper (Cu)	2019/07/16	<1.0		ug/L	
			Total Iron (Fe)	2019/07/16	<50		ug/L	
			Total Lead (Pb)	2019/07/16	<0.20		ug/L	
			Total Lithium (Li)	2019/07/16	<5.0		ug/L	
			Total Manganese (Mn)	2019/07/16	<1.0		ug/L	
			Total Molybdenum (Mo)	2019/07/16	<0.50		ug/L	
			Total Nickel (Ni)	2019/07/16	<1.0		ug/L	
			Total Phosphorus (P)	2019/07/16	<50		ug/L	
			Total Selenium (Se)	2019/07/16	<0.40		ug/L	
			Total Silicon (Si)	2019/07/16	<500		ug/L	
			Total Silver (Ag)	2019/07/16	<0.10		ug/L	
			Total Strontium (Sr)	2019/07/16	0.54, RDL=0.50 (3)		ug/L	
			Total Thallium (Tl)	2019/07/16	<0.020		ug/L	
			Total Tin (Sn)	2019/07/16	<2.0		ug/L	

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Titanium (Ti)	2019/07/16	<20		ug/L	
			Total Uranium (U)	2019/07/16	<0.050		ug/L	
			Total Vanadium (V)	2019/07/16	<2.0		ug/L	
			Total Zinc (Zn)	2019/07/16	<10		ug/L	
			Total Zirconium (Zr)	2019/07/16	<1.0		ug/L	
			Total Sulphur (S)	2019/07/16	<6000		ug/L	
9494808	EL2	Spiked Blank	Total Mercury (Hg)	2019/07/10		83	%	80 - 120
9494808	EL2	RPD	Total Mercury (Hg)	2019/07/10	20		%	20
			Total Mercury (Hg)	2019/07/10	NC		%	20
9494808	EL2	Method Blank	Total Mercury (Hg)	2019/07/10	<0.020		ug/L	
9518064	CJY	Spiked Blank	Total Mercury (Hg)	2019/07/29		92	%	80 - 120
9518064	CJY	RPD	Total Mercury (Hg)	2019/07/29	0.77		%	20
			Total Mercury (Hg)	2019/07/29	NC (4)		%	20
9518064	CJY	Method Blank	Total Mercury (Hg)	2019/07/29	<0.020 (4)		ug/L	

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

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.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

(2) Reagent Blank exceeds acceptance limits for (Barium) - 2X RDL acceptable for low level metals determination.

(3) Reagent Blank exceeds acceptance limits for (Strontium) - 2X RDL acceptable for low level metals determination.

(4) Detection limit raised based on sample volume used for analysis.

Your C.O.C. #: 08470876

Attention: Tony Walker

DALHOUSIE UNIVERSITY
WATER RESOURCE STUDIES
PO 15000 (D401)
1360 BARRINGTON ST
HALIFAX, NS
CANADA B3H 4R2

Report Date: 2019/07/26
Report #: R2758351
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

BV LABS JOB #: B941369
Received: 2019/05/30, 09:45

Sample Matrix: Water
Samples Received: 18

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Mercury (Total) by CV	18	2019/06/07	2019/06/13	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Elements by ICPMS Digested LL (total)	9	2019/06/05	2019/06/07	BBY7SOP-00003 / BBY7SOP-00002	EPA 6020b R2 m

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in BV Labs profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and BV Labs in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by BV Labs, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

MERCURY BY COLD VAPOR (WATER)

BV Labs ID		VT8226	VT8227	VT8228	VT8229	VT8230	VT8231	VT8232		
Sampling Date		2019/05/28 09:20	2019/05/28 09:25	2019/05/28 09:35	2019/05/28 09:42	2019/05/28 09:48	2019/05/28 09:57	2019/05/28 10:05		
COC Number		08470876	08470876	08470876	08470876	08470876	08470876	08470876		
	UNITS	ESM-1	ESM-2	ESM-3	ESM-4	ESM-5	ESM-6	ESM-7	RDL	QC Batch
Elements										
Total Mercury (Hg)	ug/L	<0.020 (1)	<0.020 (1)	<0.020 (1)	<0.020 (1)	<0.020 (1)	<0.020 (1)	<0.020 (1)	0.020	9454183

RDL = Reportable Detection Limit
(1) Detection limit raised due to interferent.

BV Labs ID		VT8233	VT8234		VT8236		VT8237	VT8238	VT8239		
Sampling Date		2019/05/28 10:09	2019/05/28 10:15		2019/05/28 09:20		2019/05/28 09:25	2019/05/28 09:35	2019/05/28 09:42		
COC Number		08470876	08470876		08470876		08470876	08470876	08470876		
	UNITS	ESM-8	ESM-9	RDL	ES HG-1	RDL	ES HG-2	ES HG-3	ES HG-4	RDL	QC Batch
Elements											
Total Mercury (Hg)	ug/L	<0.020 (1)	<0.020 (1)	0.020	0.0078 (1)	0.0020	<0.020 (1)	<0.020 (1)	<0.020 (1)	0.020	9454183

RDL = Reportable Detection Limit
(1) Detection limit raised due to interferent.

BV Labs ID		VT8240	VT8241	VT8242	VT8244	VT8245		
Sampling Date		2019/05/28 09:48	2019/05/28 09:57	2019/05/28 10:05	2019/05/28 10:15	2019/05/28 10:18		
COC Number		08470876	08470876	08470876	08470876	08470876		
	UNITS	ES HG-5	ES HG-6	ES HG-7	ES HG-9	ES HG-10	RDL	QC Batch
Elements								
Total Mercury (Hg)	ug/L	<0.020 (1)	<0.020 (1)	<0.020 (1)	<0.020 (1)	<0.020 (1)	0.020	9454183

RDL = Reportable Detection Limit
(1) Detection limit raised due to interferent.

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

BV Labs ID		VT8226	VT8227	VT8228	VT8229	VT8230	VT8231	VT8232		
Sampling Date		2019/05/28 09:20	2019/05/28 09:25	2019/05/28 09:35	2019/05/28 09:42	2019/05/28 09:48	2019/05/28 09:57	2019/05/28 10:05		
COC Number		08470876	08470876	08470876	08470876	08470876	08470876	08470876		
	UNITS	ESM-1	ESM-2	ESM-3	ESM-4	ESM-5	ESM-6	ESM-7	RDL	QC Batch
Total Metals by ICPMS										
Total Aluminum (Al)	ug/L	161	176	105	160	139	98	96	30	9449329
Total Antimony (Sb)	ug/L	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.20	9449329
Total Arsenic (As)	ug/L	3.93	4.33	2.90	4.11	4.15	3.23	3.87	0.20	9449329
Total Barium (Ba)	ug/L	110	151	153	100	91.8	50.8	55.6	0.50	9449329
Total Beryllium (Be)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	9449329
Total Bismuth (Bi)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	9449329
Total Boron (B)	ug/L	<100	<100	<100	<100	<100	<100	<100	100	9449329
Total Cadmium (Cd)	ug/L	0.069	0.081	0.093	0.118	0.110	0.100	0.106	0.050	9449329
Total Chromium (Cr)	ug/L	2.1	1.8	2.0	2.0	1.7	1.7	1.8	1.0	9449329
Total Cobalt (Co)	ug/L	0.33	0.23	0.18	0.21	0.31	0.15	0.19	0.10	9449329
Total Copper (Cu)	ug/L	2.1	<1.0	<1.0	1.0	1.5	<1.0	<1.0	1.0	9449329
Total Iron (Fe)	ug/L	<50	61	<50	62	57	<50	<50	50	9449329
Total Lead (Pb)	ug/L	1.37	1.85	2.15	1.84	1.77	1.28	1.62	0.20	9449329
Total Lithium (Li)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	9449329
Total Manganese (Mn)	ug/L	1980	1950	1340	1230	1370	636	585	1.0	9449329
Total Molybdenum (Mo)	ug/L	8.34	12.8	10.0	14.0	14.1	12.7	16.0	0.50	9449329
Total Nickel (Ni)	ug/L	3.0	1.3	1.2	1.5	1.7	1.3	<1.0	1.0	9449329
Total Phosphorus (P)	ug/L	205	245	180	212	230	156	186	50	9449329
Total Selenium (Se)	ug/L	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	0.40	9449329
Total Silicon (Si)	ug/L	<500	508	<500	<500	<500	<500	<500	500	9449329
Total Silver (Ag)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	9449329
Total Strontium (Sr)	ug/L	106	125	95.7	130	127	92.1	115	0.50	9449329
Total Thallium (Tl)	ug/L	0.097	0.063	0.049	0.052	0.032	0.031	0.027	0.020	9449329
Total Tin (Sn)	ug/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.0	9449329
Total Titanium (Ti)	ug/L	336	410	337	418	414	295	381	20	9449329
Total Uranium (U)	ug/L	0.748	1.22	1.40	1.29	1.42	1.19	1.23	0.050	9449329
Total Vanadium (V)	ug/L	3.8	4.4	2.6	4.1	4.1	3.2	3.2	2.0	9449329
Total Zinc (Zn)	ug/L	14	14	14	13	16	10	11	10	9449329
Total Zirconium (Zr)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	9449329
Total Sulphur (S)	ug/L	<6000	<6000	<6000	<6000	<6000	<6000	<6000	6000	9449329
RDL = Reportable Detection Limit										

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

BV Labs ID		VT8233	VT8234		
Sampling Date		2019/05/28 10:09	2019/05/28 10:15		
COC Number		08470876	08470876		
	UNITS	ESM-8	ESM-9	RDL	QC Batch
Total Metals by ICPMS					
Total Aluminum (Al)	ug/L	56	58	30	9449329
Total Antimony (Sb)	ug/L	<0.20	<0.20	0.20	9449329
Total Arsenic (As)	ug/L	3.41	2.96	0.20	9449329
Total Barium (Ba)	ug/L	32.5	41.1	0.50	9449329
Total Beryllium (Be)	ug/L	<0.10	<0.10	0.10	9449329
Total Bismuth (Bi)	ug/L	<0.10	<0.10	0.10	9449329
Total Boron (B)	ug/L	<100	<100	100	9449329
Total Cadmium (Cd)	ug/L	0.116	0.080	0.050	9449329
Total Chromium (Cr)	ug/L	2.0	1.8	1.0	9449329
Total Cobalt (Co)	ug/L	0.18	0.36	0.10	9449329
Total Copper (Cu)	ug/L	1.0	<1.0	1.0	9449329
Total Iron (Fe)	ug/L	<50	<50	50	9449329
Total Lead (Pb)	ug/L	1.41	1.20	0.20	9449329
Total Lithium (Li)	ug/L	<5.0	<5.0	5.0	9449329
Total Manganese (Mn)	ug/L	202	2280	1.0	9449329
Total Molybdenum (Mo)	ug/L	15.4	16.2	0.50	9449329
Total Nickel (Ni)	ug/L	1.1	1.3	1.0	9449329
Total Phosphorus (P)	ug/L	142	152	50	9449329
Total Selenium (Se)	ug/L	<0.40	<0.40	0.40	9449329
Total Silicon (Si)	ug/L	<500	<500	500	9449329
Total Silver (Ag)	ug/L	<0.10	<0.10	0.10	9449329
Total Strontium (Sr)	ug/L	95.6	86.2	0.50	9449329
Total Thallium (Tl)	ug/L	<0.020	<0.020	0.020	9449329
Total Tin (Sn)	ug/L	<2.0	<2.0	2.0	9449329
Total Titanium (Ti)	ug/L	346	361	20	9449329
Total Uranium (U)	ug/L	1.26	1.38	0.050	9449329
Total Vanadium (V)	ug/L	3.2	2.7	2.0	9449329
Total Zinc (Zn)	ug/L	<10	11	10	9449329
Total Zirconium (Zr)	ug/L	<1.0	<1.0	1.0	9449329
Total Sulphur (S)	ug/L	<6000	<6000	6000	9449329
RDL = Reportable Detection Limit					

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
9449329	VBA	Spiked Blank	Total Aluminum (Al)	2019/06/21		98	%	80 - 120
			Total Antimony (Sb)	2019/06/21		91	%	80 - 120
			Total Arsenic (As)	2019/06/21		91	%	80 - 120
			Total Barium (Ba)	2019/06/21		91	%	80 - 120
			Total Beryllium (Be)	2019/06/21		88	%	80 - 120
			Total Bismuth (Bi)	2019/06/21		87	%	80 - 120
			Total Boron (B)	2019/06/21		83	%	80 - 120
			Total Cadmium (Cd)	2019/06/21		88	%	80 - 120
			Total Chromium (Cr)	2019/06/21		89	%	80 - 120
			Total Cobalt (Co)	2019/06/21		86	%	80 - 120
			Total Copper (Cu)	2019/06/21		82	%	80 - 120
			Total Iron (Fe)	2019/06/21		9.5 (1)	%	80 - 120
			Total Lead (Pb)	2019/06/21		87	%	80 - 120
			Total Lithium (Li)	2019/06/21		88	%	80 - 120
			Total Manganese (Mn)	2019/06/21		87	%	80 - 120
			Total Molybdenum (Mo)	2019/06/21		98	%	80 - 120
			Total Nickel (Ni)	2019/06/21		86	%	80 - 120
			Total Phosphorus (P)	2019/06/21		11 (1)	%	80 - 120
			Total Selenium (Se)	2019/06/21		89	%	80 - 120
			Total Silicon (Si)	2019/06/21		11 (1)	%	80 - 120
			Total Silver (Ag)	2019/06/21		86	%	80 - 120
			Total Strontium (Sr)	2019/06/21		93	%	80 - 120
			Total Thallium (Tl)	2019/06/21		87	%	80 - 120
			Total Tin (Sn)	2019/06/21		90	%	80 - 120
			Total Titanium (Ti)	2019/06/21		88	%	80 - 120
			Total Uranium (U)	2019/06/21		90	%	80 - 120
			Total Vanadium (V)	2019/06/21		86	%	80 - 120
			Total Zinc (Zn)	2019/06/21		86	%	80 - 120
			Total Zirconium (Zr)	2019/06/21		83	%	80 - 120
			Total Sulphur (S)	2019/06/21		84	%	80 - 120
9449329	VBA	RPD	Total Aluminum (Al)	2019/06/21	1.3		%	20
			Total Antimony (Sb)	2019/06/21	104 (1)		%	20
			Total Arsenic (As)	2019/06/21	23 (1)		%	20
			Total Barium (Ba)	2019/06/21	0.68		%	20
			Total Beryllium (Be)	2019/06/21	2.8		%	20
			Total Bismuth (Bi)	2019/06/21	63 (1)		%	20
			Total Boron (B)	2019/06/21	2.7		%	20
			Total Cadmium (Cd)	2019/06/21	5.3		%	20
			Total Chromium (Cr)	2019/06/21	11		%	20
			Total Cobalt (Co)	2019/06/21	9.3		%	20
			Total Copper (Cu)	2019/06/21	7.9		%	20
			Total Iron (Fe)	2019/06/21	156 (1)		%	20
			Total Lead (Pb)	2019/06/21	2.6		%	20
			Total Lithium (Li)	2019/06/21	13		%	20
			Total Manganese (Mn)	2019/06/21	14		%	20
			Total Molybdenum (Mo)	2019/06/21	158 (1)		%	20
			Total Nickel (Ni)	2019/06/21	5.4		%	20
			Total Phosphorus (P)	2019/06/21	94 (1)		%	20
			Total Selenium (Se)	2019/06/21	20		%	20
			Total Silicon (Si)	2019/06/21	0		%	20
			Total Silver (Ag)	2019/06/21	11		%	20
			Total Strontium (Sr)	2019/06/21	5.1		%	20
			Total Thallium (Tl)	2019/06/21	18		%	20
			Total Tin (Sn)	2019/06/21	155 (1)		%	20
			Total Titanium (Ti)	2019/06/21	168 (1)		%	20

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Uranium (U)	2019/06/21	24 (1)		%	20
			Total Vanadium (V)	2019/06/21	12		%	20
			Total Zinc (Zn)	2019/06/21	2.8		%	20
			Total Zirconium (Zr)	2019/06/21	148 (1)		%	20
			Total Sulphur (S)	2019/06/21	0		%	20
			Total Aluminum (Al)	2019/06/21	NC		%	20
			Total Antimony (Sb)	2019/06/21	NC		%	20
			Total Arsenic (As)	2019/06/21	143 (1)		%	20
			Total Barium (Ba)	2019/06/21	93 (1)		%	20
			Total Beryllium (Be)	2019/06/21	NC		%	20
			Total Bismuth (Bi)	2019/06/21	NC		%	20
			Total Boron (B)	2019/06/21	NC		%	20
			Total Cadmium (Cd)	2019/06/21	NC		%	20
			Total Chromium (Cr)	2019/06/21	18		%	20
			Total Cobalt (Co)	2019/06/21	NC		%	20
			Total Copper (Cu)	2019/06/21	NC		%	20
			Total Iron (Fe)	2019/06/21	NC		%	20
			Total Lead (Pb)	2019/06/21	146 (1)		%	20
			Total Lithium (Li)	2019/06/21	NC		%	20
			Total Manganese (Mn)	2019/06/21	NC		%	20
			Total Molybdenum (Mo)	2019/06/21	NC		%	20
			Total Nickel (Ni)	2019/06/21	NC		%	20
			Total Phosphorus (P)	2019/06/21	NC		%	20
			Total Selenium (Se)	2019/06/21	NC		%	20
			Total Silicon (Si)	2019/06/21	NC		%	20
			Total Silver (Ag)	2019/06/21	NC		%	20
			Total Strontium (Sr)	2019/06/21	162 (1)		%	20
			Total Thallium (Tl)	2019/06/21	NC		%	20
			Total Tin (Sn)	2019/06/21	NC		%	20
			Total Titanium (Ti)	2019/06/21	181 (1)		%	20
			Total Uranium (U)	2019/06/21	NC		%	20
			Total Vanadium (V)	2019/06/21	NC		%	20
			Total Zinc (Zn)	2019/06/21	NC		%	20
			Total Zirconium (Zr)	2019/06/21	NC		%	20
			Total Sulphur (S)	2019/06/21	NC		%	20
9449329	VBA	Method Blank	Total Aluminum (Al)	2019/06/21	<30		ug/L	
			Total Antimony (Sb)	2019/06/21	<0.20		ug/L	
			Total Arsenic (As)	2019/06/21	<0.20		ug/L	
			Total Barium (Ba)	2019/06/21	0.81, RDL=0.50		ug/L	
			Total Beryllium (Be)	2019/06/21	<0.10		ug/L	
			Total Bismuth (Bi)	2019/06/21	<0.10		ug/L	
			Total Boron (B)	2019/06/21	<100		ug/L	
			Total Cadmium (Cd)	2019/06/21	<0.050		ug/L	
			Total Chromium (Cr)	2019/06/21	1.4, RDL=1.0		ug/L	
			Total Cobalt (Co)	2019/06/21	<0.10		ug/L	
			Total Copper (Cu)	2019/06/21	<1.0		ug/L	
			Total Iron (Fe)	2019/06/21	<50		ug/L	
			Total Lead (Pb)	2019/06/21	<0.20		ug/L	
			Total Lithium (Li)	2019/06/21	<5.0		ug/L	
			Total Manganese (Mn)	2019/06/21	<1.0		ug/L	
			Total Molybdenum (Mo)	2019/06/21	<0.50		ug/L	
			Total Nickel (Ni)	2019/06/21	<1.0		ug/L	
			Total Phosphorus (P)	2019/06/21	<50		ug/L	

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Selenium (Se)	2019/06/21	<0.40		ug/L	
			Total Silicon (Si)	2019/06/21	<500		ug/L	
			Total Silver (Ag)	2019/06/21	<0.10		ug/L	
			Total Strontium (Sr)	2019/06/21	<0.50		ug/L	
			Total Thallium (Tl)	2019/06/21	<0.020		ug/L	
			Total Tin (Sn)	2019/06/21	<2.0		ug/L	
			Total Titanium (Ti)	2019/06/21	<20		ug/L	
			Total Uranium (U)	2019/06/21	<0.050		ug/L	
			Total Vanadium (V)	2019/06/21	<2.0		ug/L	
			Total Zinc (Zn)	2019/06/21	<10		ug/L	
			Total Zirconium (Zr)	2019/06/21	<1.0		ug/L	
			Total Sulphur (S)	2019/06/21	<6000		ug/L	
9454183	EL2	Spiked Blank	Total Mercury (Hg)	2019/06/13		72 (1)	%	80 - 120
9454183	EL2	RPD	Total Mercury (Hg)	2019/06/13	2.4		%	20
			Total Mercury (Hg)	2019/06/13	NC (2)		%	20
9454183	EL2	Method Blank	Total Mercury (Hg)	2019/06/13	<0.020 (2)		ug/L	

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

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.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

(2) Detection limit raised due to interferent.