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Methods and Results for Metals, Polycyclic Aromatic Hydrocarbons, Polychlorinated Biphenyls and Chlorinated Pesticides in 2015 & 2016 Surface Sediments and Sediment Cores of the Mactaquac Headpond.

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DISCLAIMER

Intended use and technical limitations of the report, "Methods and Results for Metals, Polycyclic Aromatic Hydrocarbons, Polychlorinated Biphenyls and Chlorinated Pesticides in 2015 & 2016 Surface Sediments and Sediment Cores of the Mactaquac Headpond". This report describes surface sediment and core sediment chemistry methods and analyses conducted in the MAES project in 2015/6. It is intend to support the developing hydrodynamic models and it is not a comprehensive, spatial assessment. The CRI doesn't assume liability for any use of the included data or analyses outside the stated scope.

Introduction

The Report: The following report focuses on the contaminants and nutrients found in surface sediments and sediment cores from the headpond above the Mactaquac Dam on the Saint John River, New Brunswick as well as comparisons to surface sediments from four nearby reference lakes. The report is linked to the CRI NB Power contract item 1.3.1 - Assess Current Sediment Accumulation and Chemical Composition (a database), 1.3.1.1 – A sediment survey, and 1.3.1.2 A map of sediment accumulation and chemical composition. This report describes the surface sediment and core sediment chemistry methods and analyses; data are available in the MAES Data Management System.

The main contaminants of interest are a suite of metals, chlorinated pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and nutrients (nitrogen (N) and phosphorous (P)) that have natural (metals, PAHs, nutrients) and human (metals, chlorinated pesticides, PAHs, PCBs, nutrients) sources in the watershed. Many of these contaminants have Canadian Council of Ministers of the Environment (CCME) sediment quality guidelines that can be used to assess whether levels in the headpond are above thresholds of concern; concentrations above the guidelines may have effects on sediment-dwelling organisms. In addition, the CCME has soil quality guidelines for some contaminants below which the soils are considered to be protective of ecological receptors and humans and these were included for reference herein. The report describes the results from 2015 sampling and analyses of surface sediments from 15 sites (11 in the headpond and 4 reference lakes) and the 2016 collection and analyses of sediment cores from 6 sites in the headpond for these contaminants. The goals of this sampling were two-fold: 1) to assess whether there were any sites with higher contaminants than others (potential sites of concern/hotspots), and 2) to understand whether any contaminants exceeded the CCME sediment or soil quality guideline values.

Background: Pesticides are produced and used to control pest insects, weeds, fungi, etc. in agricultural, forestry, and urban areas. Although current-use pesticides tend to be short-lived in the environment, some of the pesticides used in the 1950s through 1970s in Canada (i.e., chlorinated pesticides like DDT) are not easily degraded in the environment and thus will persist for years in soils at sites of application. These chlorinated pesticides enter rivers via overland runoff and erosion of soils and are deposited and accumulated in aquatic sediments where they can persist for many years. They also have the properties (high affinities for fats) to concentrate through aquatic food webs (biomagnification) to potentially toxic levels in upper-trophic-level species (e.g., fish, fish-eating birds). Although these pesticides have been banned from use in Canada for several decades, they are still found in the environment. They tend to be widely distributed because of their high historical use and ability to be transported long distances by wind and water currents from areas where they were used or are still used outside of Canada (i.e., DDT is still used for malaria control). Some of these chlorinated pesticides were used in New Brunswick. For example, the insecticide DDT was used from 1952-1966 to control spruce budworm; however, during the latter few years its use was restricted to areas away from streams because of concerns over its effects on fishes (Keachie and Côté, 1973).

PAHs are a complex group of aromatic contaminants that are naturally present in fossil fuels (oil, coal, gas). They are also created when fossil fuels, wood, and garbage are burned, and they are released by industries (e.g., coking ovens), incinerators, processing of asphalts, and households (i.e., wood stoves, barbecues). As a result, they have both natural and human sources in surface waters. These compounds are of concern as they are persistent in the environment, accumulating and persisting in soils and sediments, and some forms are believed to be carcinogenic (e.g. benzo[a]pyrene) and immunotoxic.

PCBs were once widely used in North America as coolants and lubricants for transformers and capacitors, and in hydraulic fluids, carbonless copy paper, plastics, caulking, paints, and other products because of their resistance to heat and chemical stability. Some local sources in the Saint John River valley include their historical use in paints at the Mactaquac hatchery and as evaporation retardants in pesticides (Keachie and Côté, 1973). There are 209 different PCBs that have between 1 and 10 chlorines. Their import, use, release and storage in Canada have been regulated since the late 1970s. Although they are all very persistent in the environment, PCBs with more chlorines tend to be more persistent and will concentrate more readily through food webs. There are concerns globally that these chemicals have accumulated to harmful levels in top predators of some aquatic food webs (e.g., birds, mammals) and affected their ability to reproduce.

Metals are present naturally in soils and rocks and they leach into aquatic environments through geological weathering and overland runoff. Therefore, the natural composition of the land will influence what is found in nearby surface and ground waters. In New Brunswick, there are natural sources of several metals (e.g., lead, aluminum, iron, nickel, copper, zinc, arsenic, mercury and cadmium) that influence what is found in waters and their sediments (Travers, 1976; Keachie and Côté, 1973; NB Department of Environment 2008; Kidd et al. 2011). However, aquatic environments can also become contaminated with metals through human activities such as mining (e.g., Lake George antimony mine; Travers, 1976), smelters (e.g., Belldune, NB; Bonham-Carter et al., 2005), other industrial discharges, agriculture (fertilizers, pesticides, composts, sludge and manures; Wuana and Okieimen, 2011), and municipal wastewater effluents. Agricultural runoff or direct discharges from industries and municipalities can result in the contamination of surface waters with metals. A review of water quality data from the Saint John River found similar concentrations of aluminum, iron, copper, zinc and lead in water across sites (2000-08), suggesting that the recent inputs of these metals are from natural sources (Kidd et al. 2011). Some historical water data (1970s-90s) were higher at a few sites in the river, suggesting some historical inputs of metals from human activities (Kidd et al. 2011). Many metals bind to particulates and therefore will accumulate in soils and sediments; they do not degrade and therefore will remain and cycle in the aquatic environment.

Mercury is a metal of particular concern because it is transformed in the aquatic environment to a form – methyl mercury – that will biomagnify through food webs and reach concentrations that may be toxic to the fish and fish-eating wildlife and humans. Anthropogenic sources of mercury in the Saint John River may include wastes from the following industries: coal mining (existed in Saint John River basin until 2009; Stone, 2010), other mining (Travers, 1976), agriculture, pulp and paper mills and food processing. Other sources include household waste and domestic sewage effluents (Health Canada, 2009). Mercury is also found naturally in volcanic rock deposits and deposition from forest fires (Health Canada, 2009). Until the early 1970s, mercury was in fungicides and other agricultural products used in the Saint John River valley. Even though these pesticides are not used today, they may still be contaminating the river system through overland runoff (Travers, 1976).

As for nutrients, nitrogen (N) and phosphorous (P) have both natural and human sources to surface waters. Municipal wastewater discharges and overland runoff of fertilizers from domestic and agricultural use are the main human sources of these nutrients to freshwaters, and can lead to eutrophication (algal blooms) where excessive concentrations occur. A review of the historical and recent concentrations of N and P in the river is reported in Kidd et al. (2011). This review indicated elevated aqueous concentrations of these nutrients in the river from the 1960s to 1980s, and more recent reductions in concentrations with the improved treatment of municipal wastewaters and industrial effluents (Kidd et al. 2011). Despite these improvements, water concentrations of these nutrients were still above "ideal" levels in reaches upstream from the Mactaquac dam in the early 2000s (Kidd et al. 2011).

Methods

<u>Chemical Analysis of Sediments</u>

Surface sediments were collected in the 2015 from 9 sites in the headpond, 2 sites downstream of the headpond (sites 32 and 33) and from 4 reference lakes (Figure 1). These lakes were Davidson Lake (site 34), Little Magaguadavic Lake (site 35), Skiff Lake (site 36) and Miramichi Lake (site 38), and were chosen for their proximity to the headpond and accessibility. A dredge was used to collect sediments, and from that a clean core tube was used to obtain a subsample of the top 5 cm. This sample was placed in a pre-cleaned glass jar, kept on ice in the field, and then frozen upon return to the lab until used for analysis. Five samples were collected per site on the headpond and at the deepest part of each reference lake. Additional details on the sampling are provided in *MAES Report Series 2015-003, METHODS PAPER: Reservoir Sediment Sampling*.

Sediment core samples were collected from the headpond at 2 sites in February 2016 (Long Creek and Riverside) and at 4 sites in June 2016 (Snowshoe Island, Bear Island, Nackawic AVN below (NB-AVN) and Nackawic AVN up (AVN-UP); Figure 2). Sediment cores were sampled using a gravity corer and clean coring tubes at each site. The Long Creek and Riverside cores were extruded to 0.5 cm increments and the Snowshoe Island, Bear Island, NB-AVN and AVN-UP were extruded to 1.0 cm increments for chemical analysis on the same day as they were collected. All core slices were place in Whirlpak bags and immediately frozen until analysis was completed. The number of slices and depths analyzed varied among cores and details are given below. For all cores, surface and deeper sediments were analyzed to assess whether deeper and presumably older sediments had different contaminant concentrations than shallower and presumably newer sediments. Deeper slices were selected based on changes in the visual appearance of the sediment grain size, colour, and/or the presence of vegetative matter. No dating of these cores has been done to determine years that these sediments were deposited so we have reasonably assumed that deeper slices represent historical deposition as is typical of a deep lake environment.

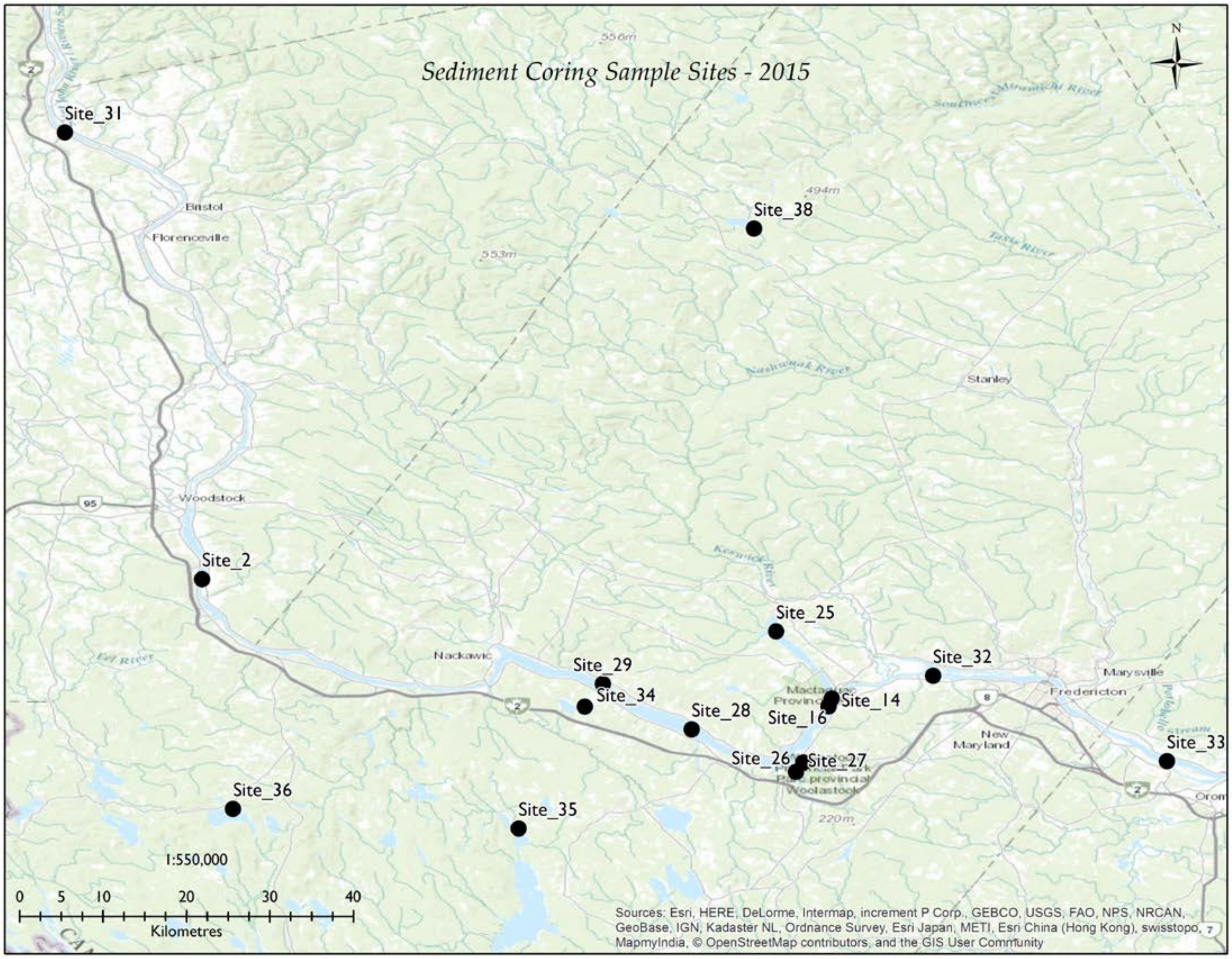

Figure 1: Locations of sites for sediment sampling in 2015.

Frozen sediment samples (surface and cores) were thawed prior to analyses and macroinvertebrates or debris (e.g., pieces of wood or plastic) were manually removed. All percent moisture, metal, PAH, PCB, and pesticide analyses were done in the Environmental Chemistry Lab at the Canadian Rivers Institute (CRI), University of New Brunswick Saint John using the same methods as those used for the 2014 samples (MAES Report: 2016-031; Kidd et al. 2016). The 2015 and 2016 sediment samples were run for the same individual contaminants as described in the previous report, as well as two additional PCB congeners (see below). Sediments were subsampled and analysed for % organic carbon, % inorganic carbon and total Kjeldahl (TKN) at RPC in Fredericton.

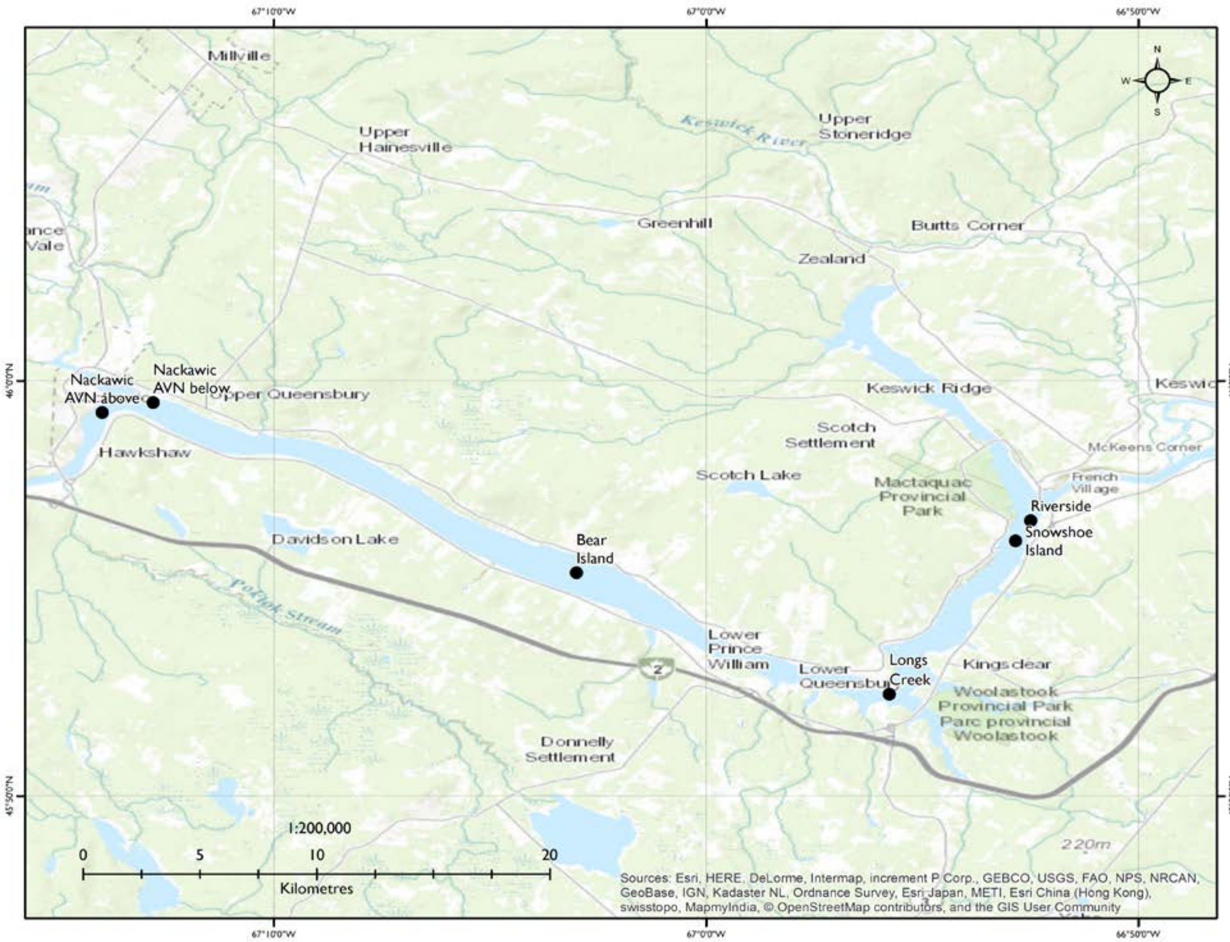

Figure 2: Locations of sites for sediment core sampling in 2016.

Moisture Content

An empty container was weighed (Sartorius CP323S balance) and then reweighed with the wet sample. The container was covered with a Kimwipe and then placed in the freeze dryer (Labconco FreezeZone12) for a minimum of three days. The container was re-weighed and the percent moistures were calculated as follows:

$$\%\ Moisture = \left(1 - \left[\frac{(weight\ of\ container + dry\ sample) - weight\ of\ container}{(weight\ of\ container + wet\ sample) - weight\ of\ container}\right]\right) x\, 100\%$$

After freeze drying, the sample was homogenized using a dried, acid washed glass mortar and pestle. Aliquots of the dried sample were removed for determination of metals/elements, total mercury (Hg), PAHs, chlorinated pesticides and PCBs. Sample requirements and methods for the different physicochemical analyses are summarized in Table 1 and described in detail in subsequent sections.

Table 1: Summary of physicochemical analysis of sediment samples by CRI, UNB Saint John.

Test	Mass of sample	Unit Reported	Method Used
Moisture	100 g wet	%	Gravimetric
Elements (Metals)	0.5 g dry	mg/kg-dw	Digestion and ICP-OES quantification based on US EPA 3051, 200.7, and 6010C methods
Total Hg	0.03 g dry	µg/kg-dw	DMA-80 based on US EPA 7473 method
PAHs	≥20 g dry	mg/kg-dw	ASE extraction, GPC cleanup and GC/MS quantification based on US EPA 3545, 3640A and 8270C methods
PCBs/Chlorinated pesticides		µg/kg-dw	ASE extraction, GPC and Florisil cleanup and GC/ECD quantification based on US EPA 3545, 3640A, 3620C, and 8082 methods

Metals and Other Elements

All individual surface sediment grabs were analyzed for metals and total mercury. Metals and total mercury were analyzed in the cores as follows: all 16 slices from the Long Creek core (0-8 cm depth, sliced at 0.5 cm increments); the top 17 slices (0-8.5 cm) and bottom 12 slices (24-30 cm) from the Riverside core (sliced at 0.5 cm increments); the 0-1 cm, 1-2 cm, 6-7 cm and 11-12 cm slices from Snowshoe Island (sliced at 1.0 cm increments); the 0-1 cm, 9-10 cm, and 18-19 cm slices from Bear Island (sliced at 1.0 cm increments); the 0-1 cm, 10-11 cm and 22-23 cm slices from NB-AVN (sliced at 1.0 cm increments); and the 0-1 cm, 8-9 cm, and 17-18 cm slices from AVN-UP (sliced at 1.0 cm increments) cores.

Sample digestion and analysis of metals followed a test method based on US Environmental Protection Agency (US EPA) standard testing protocols 3051A (US EPA, 2007a), 200.7 (US EPA, 1994a), and 6010C (US EPA, 1998a). A 0.5 g aliquot of homogenized, dried sample was digested using a microwave digestion (CEM Mars 5) and 10 mL of metal grade nitric acid (Fisher Scientific, Canada). After the digestion process, 40 mL of Milli-Q water was added along with a known amount of Yittrium (Y) (SCP Science, QC) as an internal standard. Samples were filtered using Millex syringe filters (0.45 µm) and disposable syringes with polyethylene barrels and polypropylene plungers (Fisher Scientific) into polypropylene test tubes (Fisher Scientific) for analysis. The following 22 elements were quantified using an inductively coupled plasma-optical emissions spectrophotometer (ICP-OES, iCAP 6500 Duo, Thermo Fisher Scientific) using an internal standard calibration method. Limit of quantification (LOQ; see below for explanation) and wavelengths used for quantification are listed in Table 2.

Table 2: Summary of LOQs and wavelengths for individual metals and other elements.

Element	Symbol	LOQ (mg/kg-dw)	Wavelength (λ)
aluminum	Al	<2.7	396.1
arsenic	As	<1.6	189.0
cadmium	Cd	<0.08	214.4
chromium	Cr	<0.12	267.7
cobalt	Co	<0.15	228.6
copper	Cu	<0.19	324.7
iron	Fe	<0.64	259.9
lanthanum	La	<1.0	333.7
lead	Pb	<0.77	220.3
magnesium	Mg	<4.3	279.0
manganese	Mn	<0.03	257.6
nickel	Ni	<0.13	221.6
phosphorus	P	<0.67	178.2
rubidium	Rb	<0.86	780.0
selenium	Se	<1.1	196.0
silver	Ag	<0.22	328.0
strontium	Sr	<0.004	407.7
sulphur	S	<1.1	180.7
thallium	Tl	<0.55	190.8
uranium	U	<6.4	409.0
vanadium	V	<0.15	309.3
zinc	Zn	<0.04	202.5

Quality assurance/quality control (QA/QC) procedures included the following: each batch of 11 samples included a method blank (MB), certified reference material (CRM) [National Institute of Standards & Technology (NIST) Standard Reference Material (SRM) 2702 Inorganics in Marine Sediment], calibration standard checks and sample duplicate. The MB consisted of Ottawa sand (Fisher Scientific, Ottawa, ON) which was run through the entire testing process. The target MB value was equal to or less than the LOQ. For instances where the MB was greater than the LOQ, the LOQ was increased to the level found in the blank. CRM and calibration check results were reported as percent recovery based on the certificate's certified and calculated target values. The duplicate samples were reported as relative percent differences. Instrument blanks and calibration checks were routinely done throughout the analysis. All standards (SCP Science, QC), calibration checks (SCP Science, QC), and reference materials were certified with a certificate of analysis. Instrument detection limits (IDL) were determined by running 20 repeats of a blank (IDL = $average_{blanks}$ + 3 x SD_{blanks}; based on US EPA 200.7). The LOQs were calculated as 5 times the IDL (Montaser and Golightly, 1992; see Table 2 for the LOQs).

Total Mercury

Sample preparation and analysis of THg followed a test method based on US EPA standard testing protocol 7473 (US EPA, 1998b). A 0.03 g aliquot of homogenized, dried sample was run on a direct mercury analyzer (Milestone DMA-80). Quality assurance/quality control procedures included the following. Each batch of 10 samples included an instrument blank, MB, CRM (NIST SRM 2702 Inorganics in Marine Sediment), calibration standard checks, and sample duplicate. The QA/QC procedures for the MB, CRMs, standard checks and sample duplicates followed those used for the analysis of other metals. All standards (Ultra Scientific, N. Kingstown, RI, USA), calibration checks, and reference materials were certified with a certificate of analysis. The limit of detection (LOD) was determined by averaging all the method blanks run in the batch and adding it to 3 times the SD of the method blanks for that batch (LOD 1.25 µg/kg-dw THg).

<u>Sample Preparation for PAHs, PCBs and Chlorinated Pesticides</u>

As for the 2015-2016 samples, 20 g of homogenized, dried surface sediments were extracted for all sites. For some core slices, the dry mass available was less than 20 g (ideal) or 10 g (minimum to avoid changing detection limits to values above expected concentrations of these compounds). In a few cases, a slice was combined with a subsequent slice to obtain an adequate mass for analyses (see Results for details). The pooled core samples were tested as per the analytical procedures described below. When pooled samples were less than 20 g dry weight the detection limits were increased to reflect the lower masses. For example, a 10 g sample would have detection limits that were 2 times higher than those of a 20 g sample for PAHs, PCBs and chlorinated pesticides.

Sample extraction and clean up followed a test method based on US EPA standard testing protocols 3545A (US EPA, 2007b), 3640A (US EPA, 1994b) and 3660B (US EPA, 1996d). A minimum of 10-20 g of homogenized, dried sample was spiked with a surrogate solution containing: nitrobenzene-d5, 2-fluorobiphenyl and p-terphenyl (certified standards SPEX Certiprep, Metuchen, NJ, USA) for the PAH method. It was then spiked with a second surrogate solution containing: 4-chloro-3nitrobenzotrifluoride, m-tetrachloro-m-xylene, PCB 30, PCB 103, PCB 198 and PCB 204 for the PCBs and chlorinated pesticides method (Accustandard, New Haven, CT, USA) and was then extracted using an Accelerated Solvent Extractor (Dionex ASE 300) with distilled in glass (DIG) grade 50:50 dichloromethane (DCM):acetone (Optima grade, Fisher Scientific, Ottawa, ON). Extracted samples were concentrated to 6 mL of 50:50 DCM:hexane using a Büchi rotavapor (R-200) and nitrogen evaporator (N-EVAP™112, Organomation Associates Inc.). Samples were run through a gel permeation column (J2 Scientific Automated Gel Permeation System) using 50:50 DCM:hexane to remove heavier contaminants that may interfere with the quantification of PAHs and chlorinated pesticides. The sample was then concentrated into 2.0 mL of hexane (Optima grade, Fisher Scientific) using the same techniques mentioned above. The sample was split: 1 mL was run for PAHs and 1 mL was run for PCBs and chlorinated pesticides.

<u>Polycyclic Aromatic Hydrocarbons</u>

Analysis of PAHs followed a test method based on US EPA standard testing protocol 8270C (US EPA, 1996c). The fraction was solvent transferred to isooctane using a Büchi rotavapor (R-200) and nitrogen evaporator (N-EVAPTM112, Organomation Associates Inc.) to a final volume of 1 mL. A known standardized amount of internal standard solution (naphthalene-d8, acenaphthene-d10, phenanthrene-d10, chrysene-d12 and perylene-d12) was added to each sample prior to quantification. The concentrated extracts were run on a gas chromatograph-mass spectrometer (Agilent 6890/5975B GC-MS) and quantified using an internal standard calibration and single ion monitoring mode on a DB-5, 30m x 0.25mm x 0.25µm Agilent J&W

column. Analyses included quantification of 16 PAHs using the quantification ions listed in Table 3.

Quality assurance/quality control procedures included the following. Each batch of 8 samples included a MB, Method Spike (MS) and sample duplicate. With every 10 samples a CRM (NIST SRM 1941b Organics in Marine Sediments) was included. Individual sample recoveries were determined by adding a known amount of three surrogates (nitrobenzene-d5, 2-fluorobiphenyl, p-terphenyl; certified standards SPEX Certiprep, Metuchen, NJ, USA) to each sample prior to extraction, and analyzing MBs, MSs, CRMs, and sample duplicates. The surrogates and MS were reported as percent recovery based on the calculated target concentration. CRMs were also reported as percent recovery based on target concentrations from the certificate of analysis. In addition, instrument performance was verified by running tune check standards and calibration check standards for both the target and surrogate compounds. All calibration standards, calibration check standards, tune standards, surrogate standards, and internal standards were certified (SPEX Certiprep, Metuchen, NJ, USA). Method detection limits (MDLs) for individual PAHs were determined by running 8 low level spike samples (5x higher than the expected MDL) through the entire process. The t value (n = 8, 95%) was multiplied by the standard deviation of the 8 runs to determine the MDL for each PAH (<0.01 mg/kg-dw). The MDL for total PAHs was determined by taking the square root of the sum of squares of the individual PAH MDLs (MDL <0.04 mg/kg). For the purposes of this report, data are reported as individual PAHs and individual PAHs were also summed and reported as total PAHs.

Table 3: Quantification ion used for quantifying the individual PAHs.

PAH	Quantification Ion
acenaphthene	153
acenaphthylene	152
anthracene	178
benzo[a]anthracene	228
benzo[a]pyrene	252
benzo[b]fluoranthene	252
benzo[k]fluoranthene	252
benzo[g,h,i]perylene	276
dibenzo[a,h]anthracene	278
chrysene	228
fluoranthene	202
fluorine	166
indeno[1,2,3-cd]pyrene	276
naphthalene	128
phenanthrene	178
pyrene	202

Polychlorinated Biphenyls and Chlorinated Pesticides

Analysis of PCBs and chlorinated pesticides followed a test method based on US EPA standard testing protocol 8082 (US EPA, 1996b). The 1 mL of hexane extract from above was eluted through a manually packed 1.2% deactivated (using HPLC grade water; Fisher Scientific) Florisil column (Fisher Scientific). Three fractions were collected from the Florisil column (US EPA, 1996a) using hexane to elute fraction A, 15:85 DCM:hexane to elute fraction B and 50:50 DCM:hexane to elute fraction C. Fractions A, B, and C were each concentrated into 1.0 mL of isooctane. Each fraction was spiked with a known amount of internal standard containing pentachloronitrobenzene and PCB 209 (AccuStandard, New Haven, CT, USA). The three fractions were run on a gas chromatograph-electron capture detector (Agilent 6890 GC-ECD) and quantified using an internal standard calibration on a DB-5, 60m, 0.25 mm, 0.25 µm Agilent J&W column. PCBs were verified using a GC-ECD and DB-XLB, 60m, 0.25mm, 0.25µm Agilent J&W column.

Quality assurance/quality control procedures included the following. Each batch of 8 samples included a MB, MS and sample duplicate. Every 10 samples included a CRM (NIST SRM 1941b Organics in Marine Sediments). The QA/QC procedures for the MBs, CRMs, standard checks and sample duplicates followed those listed for PAH analysis. MDLs were determined by running 8 low level spike samples (5x higher than the expected MDL) through the entire process. The t value (n = 8, 95%) was multiplied by the standard deviation of the 8 runs to determine the MDL for each PCB congener and chlorinated pesticide. The reporting limit (RL) for PCBs and chlorinated pesticides was based on the amount of the lowest calibration standard and determined to be 0.12 µg/kg-dw for each pesticide. When two or three congeners co-eluted, the RL was 0.24 or 0.36 µg/kg-dw, respectively. The MDLs were equal to or less than the RL. All calibration standards, calibration check standards, surrogate standards, and internal standards were certified (AccuStandard, New Haven, CT, USA). Tune standards were also certified (SPEX Certiprep, Metuchen, NJ, USA).

For this study, 64 individual PCB congeners were examined and those that were above detection limits were summed and reported as total PCBs (µg/kg-dw; see list in Table 4 for IUPAC congener numbers). *Note that 2 PCBs have been added to the list from the 2015 report (PCB 157 and PCB 195). Analyses included quantification of the following 26 chlorinated pesticides (see Table 4). Chlorinated pesticides were reported as individual pesticides (hexachlorobenzene, aldrin, dieldrin and methoxychlor) and ΣDDTs [sum of p,p'-dichlorodiphenyltrichloroethane (p,p'-DDT), o,p'-dichlorodiphenyltrichloroethane (o,p'-DDT), p,p'-dichlorodiphenyldichloroethylene (p,p'-DDE), o,p'-dichlorodiphenyldichloroethylene (o,p'-DDT), p,p'-dichlorodiphenyldichloroethane (p,p'-DDD) and o,p'-dichlorodiphenyldichloroethane (o,p'-DDE)], Σchlordane (sum of α-chlordane and γ-chlordane), Σendrin (sum of endrin, endrin aldehyde and endrin ketone), ΣHCH (sum of α-hexachlorocyclohexane, β- hexachlorocyclohexane, δ- hexachlorocyclohexane and γ-hexachlorocyclohexane), Σheptachlor (sum of heptachlor epoxide (isomer B) and heptachlor), Σnonachlor (sum of cis-nonachlor and trans-nonachlor) and Σendosulfan (sum of endosulfan I, endosulfan II and endosulfan sulfate). Individual chlorinated pesticides (dieldrin, heptachlor epoxide and endrin) and ΣDDD (sum of p,p'-DDD and o,p'-DDD), ΣDDE (sum of p,p'-DDE and o,p'-DDE), ΣDDT (sum of p,p'-DDT and o,p'-DDT and Σchlordane(sum of α-chlordane and γ-chlordane) were reported for comparison to the CCME or SQuiRT (US NOAA) sediment quality guidelines (see Table 15, Table 16 and Table 17).

Table 4: Individual PCBs and chlorinated pesticides that were examined in surface sediments and core samples.

PCB 8/5	PCB 83	α-HCH
PCB 18	PCB 97	hexachlorobenzene
PCB17/15	PCB 77/110	β-HCH
PCB 16/32	PCB 85	γ-HCH
PCB 28	PCB 151	δ-HCH
PCB 31	PCB 135/144	heptachlor
PCB 33	PCB 118	aldrin
PCB 53	PCB 123/149	heptachlor epoxide (Isomer B)
PCB 22	PCB 187	γ-chlordane
PCB 52	PCB 132/105	o,p'-DDE
PCB 49	PCB 153	endosulfan I
PCB 47	PCB 146	α-chlordane
PCB 48	PCB 163/138	trans-Nonachlor
PCB 44	PCB 126/178	p,p'-DDE
PCB 71/64/41	PCB 174	dieldrin
PCB 74	PCB 157*	o,p'-DDD
PCB 66/95	PCB 128/167	cis-Nonachlor
PCB 70	PCB 180	endrin
PCB 76	PCB 199	endosulfan II
PCB 91	PCB 170	p,p'-DDD
PCB 81/87	PCB 201	o,p'-DDT
PCB 56/60/92	PCB 195*	endrin aldehyde
PCB 101	PCB 194	p,p'-DDT
PCB 99	PCB 206	endosulfan sulfate
		endrin ketone
		methoxychlor

Data analysis

Data were compared against available CCME freshwater sediment or soil quality guidelines or NOAA Screening Quick Reference Table (SQuiRT) values for freshwater sediment (Buchman, 2008) when a CCME guideline did not exist. In the tables below, samples that were above these guidelines are identified. To examine the relative contaminant concentrations across surface sediment sites, samples were ranked for each contaminant in order of increasing concentration (for example, 1=lowest concentration of aluminum found across all sites). This was done both with the headpond and downstream samples only and then with the headpond, downstream and reference lake samples. The ranks were then averaged across all metals for each site and this average was used to determine the sites with the highest and lowest overall metal contamination. This ranking was then repeated for individual PAHs and pesticides and for total PCBs.

Table 5: Metals and other elements in surface sediment samples collected in 2015 from the headpond and downstream sites and reference lakes (see Figure 1). Sites are listed from upstream to downstream in the headpond. Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL. Results highlighted in red are above the CCME SQG for agricultural use.

Site # Units	n	THg (μg/kg-dw)	Al (mg/kg-dw)	As (mg/kg-dw)	Cd (mg/kg-dw)	Co (mg/kg-dw)	Cr (mg/kg-dw)	Cu (mg/kg-dw)	Fe (mg/kg-dw)
ISQG or TEL	-	170[a]	-	5.90[a]	0.60[a]	-	37.3[a]	35.7[a]	
PEL	-	486[a]	-	17.0[a]	3.50[a]	-	90.0[a]	197[a]	
SQG	-	6600[a]	-	12[a]	1.4[a]	40[a]	64[a]	63[a]	
Site 31	5	38.2 ± 14.3	20200 ±1800	5.37 ±0.34	0.08 ± 0.04	12.1 ± 0.6	**39.9 ± 2.7**	11.7 ± 1.5	27600 ± 1000
Site 2	5	25.6 ± 4.4	17600 ±700	5.01 ±0.33	0.17 ± 0.02	11.5 ± 0.4	35.5 ± 2.3	0.67 ± 0.51	26100 ± 1100
Site 29	5	88.1 ± 6.4	26500 ±1300	**9.02 ±0.50**	0.24 ± 0.03	15.0 ± 0.90	**41.5 ± 2.4**	18.9 ± 1.5	29500 ± 2100
Site 28	5	84.9 ± 4.5	29600 ±1500	**10.4 ±1.5**	0.13 ± 0.03	16.0 ± 0.70	**48.7 ± 2.2**	4.67 ± 2.65	33900 ± 1700
Site 26	5	154 ± 13	40500 ±5700	***19.0 ±3.9***	0.31 ± 0.08	19.4 ± 1.0	**58.7 ± 6.9**	7.42 ± 2.31	41900 ± 2700
Site 27	5	115 ± 4	36400 ±1300	**12.6 ±0.9**	<DL-0.10	18.8 ± 0.8	**58.1 ± 1.9**	8.66 ± 1.72	41000 ± 1500
Site 16	5	108 ± 6	33000 ±3300	**11.5 ±0.6**	0.29 ± 0.06	18.2 ± 0.2	**54.6 ± 4.3**	17.0 ± 4.4	36400 ± 2600
Site 14	5	107 ± 5	33500 ±2200	**10.6 ±0.9**	0.30 ± 0.03	17.6 ± 0.9	**56.0 ± 3.0**	12.2 ± 1.4	34700 ± 1200
Site 25	5	103 ± 12	31400 ±2300	**14.8 ±2.2**	0.30 ± 0.03	14.1 ± 1.2	**38.0 ± 3.0**	3.04 ± 1.80	32000 ± 1300
Site 32	5	41.6 ± 11.9	23400 ±2000	**9.74 ±2.40**	0.10 ± 0.06	13.2 ± 1.3	35.9 ± 2.3	<DL-3.50	23100 ± 2800
Site 33	5	12.9 ± 3.9	11900 ±1000	4.87 ±0.77	0.09 ± 0.02	9.25 ± 1.00	20.8 ± 2.2	4.06 ± 0.57	18700 ± 2200
Site 34 – ref	5	121 ± 7	35700 ±1900	**7.99 ±0.67**	0.52 ± 0.06	14.1 ± 0.5	**44.7 ± 2.5**	16.7 ± 1.9	26900 ± 1400
Site 35 – ref	5	**236 ± 7**	23500 ±1100	**7.13 ±0.52**	**0.60 ± 0.03**	10.2 ± 0.4	28.7 ± 1.5	6.79 ± 0.31	20800 ± 700
Site 36 – ref	5	146 ± 27	21400 ±2000	**9.26 ±0.83**	**1.38 ± 0.11**	10.4 ± 0.6	30.1 ± 3.8	15.5 ± 1.7	19300 ± 2200
Site 38 – ref	5	169 ± 19	18800 ±1800	**14.1 ±1.8**	**0.94 ± 0.10**	13.5 ± 1.3	18.0 ± 1.6	9.00 ± 1.02	17100 ± 1800

CCME ISQG is Interim Sediment Quality Guideline (ISQG). PEL is Probable Effects Level (CCME or NOAA SQuiRT). TEL is Threshold Effects Level (NOAA SQuiRT). SQG is the Soil Quality Guideline for agricultural use. Samples and guidelines are in mg/kg-dry weight except for THg which is μg/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples were < DLs, data are reported as a range. [a]CCME Guideline (CCME, 1998-2001; CCME, 1991-2009). [b]SQuiRT Guideline (Buchman, 2008).

Table 5 (continued): Metals and other elements in surface sediment samples collected in 2015 from the headpond and downstream sites and reference lakes (see Figure 1). Sites are listed from upstream to downstream in the headpond. Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL values. Results highlighted in red are above the CCME SQG for agricultural use.

Site # / Units	n	La (mg/kg-dw)	Mg (mg/kg-dw)	Mn (mg/kg-dw)	Ni (mg/kg-dw)	P (mg/kg-dw)	Pb (mg/kg-dw)	Rb (mg/kg-dw)	S (mg/kg-dw)
ISQG or TEL	-				18.0[b]	-	35.0[a]		
PEL	-				36.0[b]	-	91.3[a]		
SQG	-				50[a]	-	70[a]		
Site 31	5	20.2 ± 1.0	8120 ± 330	568 ± 63	***38.1 ± 1.4***	689 ± 90	13.3 ± 0.9	25.1 ± 8.0	289 ± 80
Site 2	5	18.4 ± 0.6	7670 ± 330	488 ± 70	***38.8 ± 1.6***	466 ± 45	13.4 ± 0.9	9.07 ± 1.64	191 ± 52
Site 29	5	26.8 ± 1.3	8060 ± 490	1070 ± 80	***42.9 ± 2.5***	1260 ± 80	19.8 ± 1.3	41.6 ± 13.9	725 ± 49
Site 28	5	28.7 ± 1.1	9160 ± 420	1230 ± 170	***48.5 ± 2.1***	1330 ± 80	21.1 ± 1.0	30.3 ± 1.7	617 ± 38
Site 26	5	30.3 ± 1.5	8330 ± 520	1810 ± 460	***50.2 ± 2.5***	1630 ± 170	30.0 ± 1.9	55.2 ± 11.5	971 ± 225
Site 27	5	29.3 ± 1.1	10000 ± 300	1940 ± 200	***52.9 ± 1.9***	1520 ± 60	27.1 ± 1.0	44.1 ± 1.6	839 ± 40
Site 16	5	29.4 ± 0.8	9580 ± 510	1900 ± 180	***51.5 ± 1.2***	1230 ± 110	26.1 ± 1.8	43.8 ± 11.5	897 ± 124
Site 14	5	29.3 ± 1.3	9310 ± 350	1520 ± 110	***51.2 ± 2.7***	1100 ± 70	26.9 ± 1.2	46.8 ± 5.6	598 ± 37
Site 25	5	24.4 ± 1.2	4980 ± 580	1590 ± 190	**26.7 ± 2.7**	848 ± 31	28.1 ± 0.6	42.6 ± 5.9	1060 ± 60
Site 32	5	24.5 ± 1.8	6620 ± 1010	670 ± 97	**35.5 ± 3.1**	872 ± 72	18.9 ± 1.0	33.5 ± 5.3	538 ± 181
Site 33	5	11.7 ± 1.2	5600 ± 670	399 ± 45	**27.6 ± 2.9**	451 ± 33	8.77 ± 0.98	10.5 ± 2.0	51.0 ± 7.4
Site 34 – ref	5	27.4 ± 1.1	6690 ± 320	558 ± 67	***38.0 ± 1.0***	1480 ± 50	**50.5 ± 8.3**	50.5 ± 5.5	1620 ± 360
Site 35 – ref	5	26.4 ± 1.3	4250 ± 160	1080 ± 190	**20.2 ± 0.7**	1480 ± 40	30.4 ± 1.2	26.0 ± 3.1	1170 ± 40
Site 36 – ref	5	20.5 ± 1.4	4680 ± 510	413 ± 29	**24.0 ± 1.5**	1550 ± 90	**59.0 ± 6.7**	26.6 ± 4.4	3320 ± 270
Site 38 – ref	5	15.0 ± 1.4	2330 ± 240	446 ± 52	**20.1 ± 1.9**	1740 ± 190	33.5 ± 4.0	21.5 ± 3.0	2280 ± 360

CCME ISQG is Interim Sediment Quality Guideline (ISQG). PEL is Probable Effects Level (CCME or NOAA SQuiRT). TEL is Threshold Effects Level (NOAA SQuiRT). SQG is the Soil Quality Guideline for agricultural use. Samples and guidelines are in mg/kg-dry weight except for THg which is ug/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples are < DLs, data are reported as a range. [a]CCME Guideline (CCME, 1998-2001; CCME, 1991-2009). [b]SQuiRT Guideline (Buchman, 2008).

Table 5 (continued): Metals and other elements in surface sediment samples collected in 2015 from the headpond and downstream sites and reference lakes (see Figure 1). Sites are listed from upstream to downstream in the headpond. Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL values. Results highlighted in red are above the CCME SQG for agricultural use.

Site #	n	Se	Sr	Tl	U	V	Zn
Units		(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)
ISQG or TEL	-			-		-	123[b]
PEL	-			-		-	315[b]
SQG	-			1[a]		130[a]	200[a]
Site 31	5	<DL	27.3 ± 4.2	<DL	<DL	30.8 ± 2.8	63.1 ± 4.3
Site 2	5	<DL	16.9 ± 1.4	<DL	<DL	23.8 ± 0.7	60.2 ± 4.1
Site 29	5	<DL-1.26	31.9 ± 1.6	<DL	<DL	34.0 ± 2.5	80.5 ± 5.8
Site 28	5	<DL	29.0 ± 2.2	<DL	<DL-7.18	40.8 ± 2.1	77.9 ± 5.2
Site 26	5	<DL	33.0 ± 4.7	0.83 ± 0.63	8.25 ± 2.76	58.4 ± 7.4	97.5 ± 5.2
Site 27	5	<DL	30.7 ± 1.3	1.11 ± 0.16	<DL-7.51	51.2 ± 1.6	95.2 ± 4.3
Site 16	5	<DL	32.0 ± 1.9	0.96 ± 0.23	<DL	42.5 ± 3.3	101 ± 2
Site 14	5	<DL	30.4 ± 1.8	<DL-0.76	<DL	42.7 ± 2.8	101 ± 6
Site 25	5	<DL	26.9 ± 1.9	0.85 ± 0.18	<DL	47.6 ± 2.6	77.8 ± 5.1
Site 32	5	<DL	25.0 ± 4.3	<DL	<DL	36.6 ± 2.9	47.8 ± 2.5
Site 33	5	<DL	7.78 ± 0.9	<DL	<DL	18.8 ± 1.8	45.7 ± 5.9
Site 34 – ref	5	<DL	18.6 ± 1.0	<DL	<DL	50.7 ± 3.4	118 ± 8
Site 35 – ref	5	<DL-1.29	23.9 ± 0.9	<DL-0.58	<DL	33.5 ± 1.8	110 ± 4
Site 36 – ref	5	2.24 ± 0.71	25.0 ± 2.7	<DL	<DL	37.2 ± 4.3	119 ± 9
Site 38 – ref	5	1.37 ± 0.19	18.0 ± 2.0	<DL	<DL	24.5 ± 2.0	96.0 ± 10.1

CCME ISQG is Interim Sediment Quality Guideline (ISQG). PEL is Probable Effects Level (CCME or NOAA SQuiRT). TEL is Threshold Effects Level (NOAA SQuiRT). SQG is the Soil Quality Guideline for agricultural use. Samples and guidelines are in mg/kg-dry weight except for THg which is ug/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples are < DLs, data are reported as a range. [a]CCME Guideline (CCME, 1998-2001; CCME, 1991-2009). [b]SQuiRT Guideline (Buchman, 2008).

RESULTS

Metals and Other Elements

Headpond and Downstream Surface Sediments

All of the metals and other elements analyzed in surface sediments from the headpond and downstream sites are shown in Table 5. Of the elements consistently measured across these sites, the ones at the highest concentrations were iron (18700-41900 mg/kg-dw) and aluminium (11900-40500 mg/kg-dw) and the one at the lowest concentrations (above DLs) was total mercury (12.9 to 154 μg/kg-dw). Arsenic, cadmium, cobalt, chromium, copper, lanthanum, magnesium, manganese, nickel, phosphorous, lead, rubidium, sulphur, strontium, vanadium and zinc were also measured at all sites. Based on the ranking exercise, concentrations of these elements in the headpond and downstream sites tended to be highest at sites 14, 16, 26 and 27 and lowest at sites 2, 31, 32 and 33; all sites in the former group are in a similar area of the headpond and their similar ranking suggests more local (perhaps geological) influences on sediment metal concentrations. Thallium, selenium and uranium were occasionally above detection limits at 5 (sites 14, 16, 25, 26 and 27), 1 (site 29) and 3 (sites 26, 27 and 28) sites, respectively. Silver was < DLs for all sites and is not listed in Table 5.

Of those elements with sediment quality guidelines, nickel was consistently above the PEL (NOAA SQuiRT guideline) at all sites except 25, 32 and 33 and above the soil quality guideline (CCME SQG for agricultural use) at 4 of the 11 headpond and downstream sites (Table 5). Arsenic was above the PEL for site 26, the ISQG for 8 sites, and the SQG for 3 sites (sites 25, 26 and 27). Similarly, chromium was above the ISQG for all sites but 3 (sites 2, 32 and 33). Thallium was above the soil quality guideline for site 27 only.

In general, concentrations of metals and other elements in surface sediments collected from 12 sites in the headpond in 2014 had a similar range to those analyzed from 2015 (Kidd et al. 2016). In addition, metals that exceeded ISQG or PEL values in 2014 for some sites (arsenic, chromium, nickel, thallium) also exceeded these guidelines in 2015 for a similar proportion of sites.

Reference Lake Surface Sediments

For the reference lakes (sites 34, 35, 36 and 38), iron (17100-26900 mg/kg-dw) and aluminium (18800 to 35700 mg/kg-dw) were at the highest concentrations, whereas total mercury (146 to 236 μg/kg-dw) was at the lowest concentrations (Table 5). Thallium and selenium were above detection limits at 1 and 3 sites, respectively. Arsenic, cadmium, cobalt, chromium, copper, lanthanum, magnesium, manganese, nickel, phosphorous, lead, rubidium, sulphur, strontium, vanadium and zinc were also measured above detection limits at all reference sites. All reference sites were <DL for uranium and silver (not shown).

When the reference and headpond sites were compared using the average ranks of all metals, site 34 and 14 had equal rankings and the remaining reference sites (35, 36 and 38) fell in the middle of the headpond samples. This suggests that the headpond had concentrations of metals both above and below those of the reference sites.

For nickel, all reference sites were above the ISQG (NOAA SQuirT guideline) and site 34 was above the PEL (NOAA SQuirT guideline) (Table 5). Arsenic was above the ISQG for all reference lakes and above the CCME SQG for site 38. Total mercury was above the ISQG for site 35. Cadmium was greater than the ISQG for 3 of the 4 reference lakes (sites 35, 36 and 38). The opposite trend was observed for chromium; only site 34 was above the ISQG. Lead was also above the ISQG at 2 sites (34 and 36).

Table 6: Metals and other elements in Long Creek sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL. Results highlighted in red are above the CCME SQG for agricultural use.

Depth (cm)	Moisture	THg	Al	As	Cd	Co	Cr	Cu	Fe
Units	%	(µg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)
ISQG or TEL	-	170[a]	-	5.90[a]	0.60[a]	-	37.3[a]	35.7[a]	
PEL	-	486[a]	-	17.0[a]	3.50[a]	-	90.0[a]	197[a]	
SQG	-	6600[a]	-	12[a]	1.4[a]	40[a]	64[a]	63[a]	
0.0_0.5	62.0	115	28100	**9.64**	0.10	15.8	**49.4**	17.1	34900
0.5_1.0	60.1	114	27300	**8.65**	<DL	14.5	**46.4**	15.8	32100
1.0_1.5	61.5	117	34200	**11.1**	0.08	18.2	**58.4**	21.4	40000
1.5_2.0	59.6	116	32300	**10.6**	<DL	17.4	**54.5**	19.3	37800
2.0_2.5	58.5	111	34600	**10.8**	<DL	17.8	**57.2**	19.6	38600
2.5_3.0	57.4	107	31900	**10.6**	0.14	18.9	**55.7**	**36.8**	38900
3.0_3.5	58.8	106	35500	**11.2**	0.08	19.0	**60.6**	22.4	39300
3.5_4.0	58.8	107	33600	**10.7**	0.09	18.8	**58.0**	22.5	38900
4.0_4.5	59.4	108	32600	**10.6**	0.11	18.6	**56.4**	22.9	37700
4.5_5.0	60.7	114	35000	**11.0**	<DL	19.1	**61.5**	24.7	39400
5.0_5.5	59.7	111	31400	**11.1**	0.13	19.3	**56.4**	29.5	39100
5.5_6.0	62.2	109	31400	**10.9**	0.16	17.9	**52.0**	22.4	37500
6.0_6.5	61.3	115	33500	**11.1**	0.12	18.1	**54.3**	22.4	37300
6.5_7.0	60.6	112	35000	**11.1**	0.09	18.2	**55.8**	22.0	37400
7.0_7.5	59.5	113	26800	**9.23**	0.14	15.3	**43.2**	17.9	30900
7.5_8.0	58.1	111	33400	**10.8**	0.12	17.9	**53.2**	22.2	35300

CCME ISQG is Interim Sediment Quality Guideline (ISQG). PEL is Probable Effects Level (CCME or NOAA SQuiRT). TEL is Threshold Effects Level (NOAA SQuiRT). SQG is the Soil Quality Guideline for agricultural use. Samples and guidelines are in mg/kg-dry weight except for THg which is µg/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples are < DLs, data are reported as a range. [a]CCME Guideline (CCME, 1998-2001; CCME, 1991-2009). [b]SQuiRT Guideline (Buchman, 2008).

Table 6 (continued): Metals and other elements in Long Creek sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL. Results highlighted in red are above the CCME SQG for agricultural use.

Depth (cm) Units	La (mg/kg-dw)	Mg (mg/kg-dw)	Mn (mg/kg-dw)	Ni (mg/kg-dw)	P (mg/kg-dw)	Pb (mg/kg-dw)	Rb (mg/kg-dw)	S (mg/kg-dw)	Se (mg/kg-dw)
ISQG or TEL				18.0[b]	-	35.0[a]			
PEL				36.0[b]	-	91.3[a]			
SQG				50[a]	-	70[a]			
0.0_0.5	27.6	8330	2670	***43.7***	1210	25.4	24.9	887	1.52
0.5_1.0	26.3	7860	2350	***39.6***	1120	21.5	28.9	802	1.17
1.0_1.5	32.0	9800	2930	***49.4***	1390	26.9	33.1	1020	1.73
1.5_2.0	31.2	9330	2720	***47.5***	1300	25.6	31.7	951	1.67
2.0_2.5	32.3	9740	2630	***49.1***	1330	26.3	35.8	880	1.19
2.5_3.0	30.5	9970	2640	***50.0***	1340	25.9	38.9	840	2.00
3.0_3.5	31.1	10100	2620	***50.3***	1380	27.1	45.5	847	1.88
3.5_4.0	30.5	9870	2640	***50.0***	1380	26.9	41.1	845	1.73
4.0_4.5	29.7	9670	2550	***49.4***	1370	26.7	41.1	829	1.74
4.5_5.0	29.8	10100	2670	***49.3***	1340	28.9	53.4	914	1.64
5.0_5.5	29.4	9810	2630	***49.7***	1350	28.3	47.7	941	1.65
5.5_6.0	31.3	9200	2490	***48.5***	1410	28.7	28.2	981	1.26
6.0_6.5	31.5	9290	2450	***48.4***	1450	29.1	34.2	1020	1.48
6.5_7.0	31.9	9380	2440	***48.6***	1450	29.8	38.1	1020	1.26
7.0_7.5	26.1	7740	2000	***41.0***	1250	25.1	21.2	892	<DL
7.5_8.0	30.2	9070	2240	***47.1***	1430	29.0	33.6	1030	1.61

CCME ISQG is Interim Sediment Quality Guideline (ISQG). PEL is Probable Effects Level (CCME or NOAA SQuiRT). TEL is Threshold Effects Level (NOAA SQuiRT). SQG is the Soil Quality Guideline for agricultural use. Samples and guidelines are in mg/kg-dry weight except for THg which is µg/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples are < DLs, data are reported as a range. [a]CCME Guideline (CCME, 1998-2001; CCME, 1991-2009). [b]SQuiRT Guideline (Buchman, 2008).

Table 6 (continued): Metals and other elements in Long Creek sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL. Results highlighted in red are above the CCME SQG for agricultural use.

Depth (cm)	Sr	Tl	U	V	Zn
Units	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)
ISQG or TEL		-		-	123[b]
PEL		-		-	315[b]
SQG		1[a]		130[a]	200[a]
0.0_0.5	26.1	1.39	<DL	43.1	80.7
0.5_1.0	24.7	1.25	<DL	41.2	73.8
1.0_1.5	30.9	1.68	<DL	51.8	94.0
1.5_2.0	29.3	1.60	<DL	48.8	89.4
2.0_2.5	30.5	1.62	<DL	52.0	91.7
2.5_3.0	31.3	2.08	13.9	51.3	98.0
3.0_3.5	33.8	2.27	13.3	58.0	101
3.5_4.0	32.4	2.21	13.3	55.2	99.9
4.0_4.5	31.5	2.00	12.5	53.8	99.8
4.5_5.0	32.7	2.27	8.00	59.5	107
5.0_5.5	30.4	2.10	8.12	53.5	107
5.5_6.0	30.2	1.30	<DL	49.3	96.8
6.0_6.5	31.9	1.48	<DL	52.9	96.8
6.5_7.0	32.2	1.28	<DL	54.7	96.4
7.0_7.5	25.8	0.81	<DL	41.7	79.2
7.5_8.0	31.0	1.16	<DL	51.1	92.6

CCME ISQG is Interim Sediment Quality Guideline (ISQG). PEL is Probable Effects Level (CCME or NOAA SQuiRT). TEL is Threshold Effects Level (NOAA SQuiRT). SQG is the Soil Quality Guideline for agricultural use. Samples and guidelines are in mg/kg-dry weight except for THg which is µg/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples are < DLs, data are reported as a range. [a]CCME Guideline (CCME, 1998-2001; CCME, 1991-2009). [b]SQuiRT Guideline (Buchman, 2008).

Table 7: Metals and other elements in Riverside sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL. Results highlighted in red are above the CCME SQG for agricultural use.

Depth (cm)	Moisture	THg	Al	As	Cd	Co	Cr	Cu	Fe
Units	%	(µg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)
ISQG or TEL	-	170[a]	-	5.90[a]	0.60[a]	-	37.3[a]	35.7[a]	
PEL	-	486[a]	-	17.0[a]	3.50[a]	-	90.0[a]	197[a]	
SQG	-	6600[a]	-	12[a]	1.4[a]	40[a]	64[a]	63[a]	
0.0_0.5	85.7	121	35600	***26.4***	0.28	19.7	**53.7**	20.7	42900
0.5_1.0	82.8	114	33600	***22.8***	0.20	18.1	**52.5**	21.4	40300
1.0_1.5	71.2	89	35300	**13.5**	<DL	17.5	**55.2**	19.0	37100
1.5_2.0	75.5	93	29300	**16.5**	0.19	17.7	**47.4**	18.7	37600
2.0_2.5	78.7	106	33400	***30.2***	0.21	17.9	**52.2**	18.7	41700
2.5_3.0	72.9	100	34300	**14.4**	<DL	17.8	**53.5**	19.8	38000
3.0_3.5	73.4	117	41800	***18.5***	<DL	18.9	**63.6**	23.6	41700
3.5_4.0	74.0	109	39900	**12.4**	<DL	19.0	**61.5**	21.8	39200
4.0_4.5	89.5	114	33000	**11.2**	0.14	18.8	**52.9**	20.5	37100
4.5_5.0	74.4	126	39000	**13.5**	<DL	19.2	**60.6**	22.6	38900
5.0_5.5	77.0	110	31100	**11.1**	0.10	18.6	**53.7**	25.2	38100
5.5_6.0	75.4	112	34400	**11.0**	<DL	19.2	**58.7**	23.0	39300
6.0_6.5	70.4	103	28300	**10.7**	0.21	20.1	**50.8**	22.6	40200
6.5_7.0	66.1	97	30800	**10.4**	0.11	19.0	**54.5**	22.6	39200
7.0_7.5	65.3	104	38200	**11.7**	<DL	20.4	**66.2**	25.1	42800
7.5_8.0	60.4	91	32000	**11.0**	0.09	19.2	**58.2**	23.0	39400
8.0_8.5	65.6	109	33700	**11.3**	0.09	19.5	**61.2**	22.7	39000
24.0_24.5	62.0	122	33000	**11.9**	0.15	19.7	**58.8**	24.5	39200
24.5_25.0	60.7	121	29100	**10.7**	0.19	19.6	**53.3**	24.9	38300
25.0_25.5	58.4	122	30300	**10.4**	0.20	18.4	**50.2**	22.3	34200
25.5_26.0	58.5	118	32600	**10.9**	0.08	17.8	**52.9**	21.6	32900
26.0_26.5	58.4	119	34700	**10.5**	<DL	16.6	**54.7**	19.7	31300
26.5_27.0	58.2	122	30900	**10.2**	<DL	16.7	**50.5**	19.8	31500
27.0_27.5	57.9	121	32900	**10.9**	<DL	17.9	**53.2**	21.4	32900
27.5_28.0	58.2	128	27400	**10.3**	0.21	18.0	**45.7**	22.1	32200
28.0_28.5	59.6	131	33700	**11.2**	<DL	18.5	**54.0**	23.1	33100
28.5_29.0	59.0	130	30400	**10.8**	<DL	16.9	**49.0**	19.8	30200
29.0_29.5	59.7	124	29800	**10.5**	0.15	17.6	**47.3**	22.0	30700
29.5_30.0	60.7	124	32700	**11.2**	0.15	18.7	**50.7**	24.5	32100

Table 7 (continued): Metals and other elements in Riverside sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL. Results highlighted in red are above the CCME SQG for agricultural use.

Depth (cm)	La	Mg	Mn	Ni	P	Pb	Rb	S	Se
Units	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)
ISQG or TEL				18.0[b]	-	35.0[a]			
PEL				36.0[b]	-	91.3[a]			
SQG				50[a]	-	70[a]			
0.0_0.5	32.0	9100	7760	***48.5***	1800	28.1	36.8	855	5.22
0.5_1.0	31.5	9270	3920	***48.5***	1700	25.4	34.8	746	2.50
1.0_1.5	32.4	9700	2350	***48.7***	1390	23.5	40.6	616	1.31
1.5_2.0	30.6	9060	2260	***47.9***	1560	22.9	25.5	612	1.09
2.0_2.5	30.4	8780	2910	***46.6***	2180	24.1	32.7	739	1.73
2.5_3.0	31.8	9170	2480	***49.0***	1690	24.4	39.1	678	1.56
3.0_3.5	31.6	9980	2600	***52.2***	2060	26.9	52.2	625	1.53
3.5_4.0	30.9	9810	2400	***52.2***	1650	27.4	48.3	964	1.65
4.0_4.5	30.8	9260	2330	***50.8***	1580	25.5	32.0	970	1.44
4.5_5.0	32.1	9480	2380	***51.7***	1920	28.0	45.6	1030	1.83
5.0_5.5	28.7	9700	2030	***48.9***	1370	24.3	50.8	967	1.30
5.5_6.0	29.0	10200	2140	***50.0***	1350	25.4	58.0	986	1.39
6.0_6.5	28.8	9830	2670	***50.8***	1360	25.1	32.1	865	1.65
6.5_7.0	29.7	9990	1850	***49.9***	1320	24.1	40.9	709	1.42
7.0_7.5	30.3	11200	1860	***55.0***	1410	27.7	50.9	624	1.25
7.5_8.0	32.3	10700	1600	***53.1***	1360	24.9	32.5	576	<DL
8.0_8.5	30.8	10300	1940	***52.2***	1510	26.0	47.8	879	1.19
24.0_24.5	28.9	10100	1830	***51.9***	1520	31.5	29.9	979	1.42
24.5_25.0	27.7	9770	1720	***51.4***	1500	31.0	26.1	1010	<DL
25.0_25.5	29.5	8890	1520	***50.4***	1560	30.2	27.6	1020	1.28
25.5_26.0	30.2	8730	1450	***48.7***	1520	29.4	37.8	929	1.29
26.0_26.5	28.2	8380	1350	***45.9***	1440	28.7	44.0	816	1.04
26.5_27.0	28.8	8300	1410	***46.4***	1470	29.0	33.7	784	<DL
27.0_27.5	30.3	8760	1440	***49.2***	1550	31.4	35.8	838	<DL
27.5_28.0	27.9	8300	1450	***48.7***	1530	31.9	18.6	878	1.25
28.0_28.5	30.2	8780	1470	***49.5***	1620	34.0	38.5	921	<DL
28.5_29.0	27.9	8010	1330	***45.6***	1490	30.6	30.7	833	<DL
29.0_29.5	28.4	8200	1340	***50.6***	1530	**38.1**	30.4	838	1.41
29.5_30.0	29.8	8540	1430	***52.1***	1650	**38.2**	31.9	890	<DL

Table 7 (continued): Metals and other elements in Riverside sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL. Results highlighted in red are above the CCME SQG for agricultural use.

Depth (cm)	Sr	Tl	U	V	Zn
Units	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)
ISQG or TEL		-		-	123[b]
PEL		-		-	315[b]
SQG		1[a]		130[a]	200[a]
0.0_0.5	67.3	9.27	<DL	49.2	95.9
0.5_1.0	44.9	2.82	<DL	48.9	92.2
1.0_1.5	36.6	1.06	<DL	51.7	87.5
1.5_2.0	32.3	0.98	<DL	42.6	89.0
2.0_2.5	36.2	1.75	<DL	51.1	87.2
2.5_3.0	33.9	1.32	<DL	50.6	91.7
3.0_3.5	39.3	1.29	<DL	61.3	101
3.5_4.0	36.3	1.18	<DL	59.0	101
4.0_4.5	33.5	1.08	<DL	48.2	97.9
4.5_5.0	39.3	1.19	<DL	57.6	102
5.0_5.5	32.7	1.40	<DL	49.7	99.5
5.5_6.0	33.4	1.56	<DL	55.3	103
6.0_6.5	29.4	2.10	9.39	44.5	103
6.5_7.0	29.8	1.41	<DL	49.3	96.6
7.0_7.5	32.5	1.14	<DL	60.4	104
7.5_8.0	30.0	1.12	<DL	50.6	103
8.0_8.5	33.0	1.42	<DL	54.6	111
24.0_24.5	31.3	1.26	<DL	58.0	120
24.5_25.0	29.4	1.10	<DL	51.4	121
25.0_25.5	30.0	<DL	<DL	47.9	103
25.5_26.0	30.6	0.63	<DL	51.1	98.5
26.0_26.5	30.1	0.55	<DL	54.5	91.8
26.5_27.0	28.9	<DL	<DL	48.4	95.7
27.0_27.5	31.0	<DL	<DL	50.7	103
27.5_28.0	28.5	<DL	<DL	41.9	104
28.0_28.5	32.5	0.57	<DL	51.9	108
28.5_29.0	29.0	<DL	<DL	47.0	94.8
29.0_29.5	30.0	<DL	<DL	45.5	96.0
29.5_30.0	32.7	<DL	<DL	49.4	101

Table 8: Metals and other elements in Snowshoe Island, Bear Island, NB-AVN and AVN-UP sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL. Results highlighted in red are above the CCME SQG for agricultural use.

Depth (cm)	Depth	Moisture	THg	Al	As	Cd	Co	Cr	Cu
Units	cm	%	(µg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)
ISQG or TEL		-	170[a]	-	5.90[a]	0.60[a]	-	37.3[a]	35.7[a]
PEL		-	486[a]	-	17.0[a]	3.50[a]	-	90.0[a]	197[a]
SQG		-	6600[a]	-	12[a]	1.4[a]	40[a]	64[a]	63[a]
Snowshoe Island	0.0-1.0	79.3	103	32700	**16.6**	0.09	17.0	**55.3**	21.5
Snowshoe Island	1.0-2.0	69.5	99.2	33600	**12.9**	0.08	16.8	**56.9**	21.0
Snowshoe Island	6.0-7.0	60.9	106	34300	**9.51**	0.08	17.5	**58.7**	22.5
Snowshoe Island	11.0-12.0	33.3	36.0	20500	5.66	<DL	11.5	**38.2**	12.5
Bear Island	0.0-1.0	70.5	86.1	30400	**12.0**	<DL	15.0	**50.8**	19.1
Bear Island	9.0-10.0	53.5	97.9	29400	**8.52**	<DL	14.8	**51.5**	**36.4**
Bear Island	18.0-19.0	51.2	94.5	27300	**8.56**	0.13	13.4	**47.5**	26.6
NB-AVN	0.0-1.0	67.9	80.7	27900	**10.4**	0.09	14.0	**48.2**	17.3
NB-AVN	10.0-11.0	53.9	83.2	24400	**8.32**	0.10	12.9	**43.2**	19.7
NB-AVN	22.0-23.0	44.2	66.6	24300	**7.71**	0.11	13.0	**49.5**	16.6
AVN-UP	0.0-1.0	76.8	83.5	29300	**9.39**	0.09	14.3	**50.0**	18.9
AVN-UP	8.0-9.0	43.8	40.8	17400	5.10	<DL	10.7	33.6	13.0
AVN-UP	17.0-18.0	40.7	45.4	16700	5.32	<DL	10.9	32.5	12.5

CCME ISQG is Interim Sediment Quality Guideline (ISQG). PEL is Probable Effects Level (CCME or NOAA SQuiRT). TEL is Threshold Effects Level (NOAA SQuiRT). SQG is the Soil Quality Guideline for agricultural use. Samples and guidelines are in mg/kg-dry weight except for THg which is µg/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples are < DLs, data are reported as a range. [a]CCME Guideline (CCME, 1998-2001; CCME, 1991-2009). [b]SQuiRT Guideline (Buchman, 2008).

Table 8 (continued): Metals and other elements in Snowshoe Island, Bear Island, NB-AVN and AVN-UP sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL. Results highlighted in red are above the CCME SQG for agricultural use.

Depth (cm) Units	Depth cm	Fe (mg/kg-dw)	La (mg/kg-dw)	Mg (mg/kg-dw)	Mn (mg/kg-dw)	Ni (mg/kg-dw)	P (mg/kg-dw)	Pb (mg/kg-dw)	Rb (mg/kg-dw)
ISQG or TEL						18.0[b]	-	35.0[a]	
PEL						36.0[b]	-	91.3[a]	
SQG						50[a]	-	70[a]	
Snowshoe Island	0.0-1.0	42500	31.3	10300	2550	***54.5***	1530	26.9	40.7
Snowshoe Island	1.0-2.0	40300	31.8	10500	2000	***54.3***	1420	26.6	39.9
Snowshoe Island	6.0-7.0	38100	32.3	10400	1570	***54.4***	1240	30.4	42.0
Snowshoe Island	11.0-12.0	26400	23.1	7930	794	***39.7***	770	18.4	27.3
Bear Island	0.0-1.0	35900	29.6	9420	1400	***48.0***	1340	23.0	38.4
Bear Island	9.0-10.0	34300	29.8	9470	1150	***48.8***	1250	24.5	37.1
Bear Island	18.0-19.0	30200	28.6	8950	791	***45.5***	1340	27.0	33.0
NB-AVN	0.0-1.0	32700	28.6	8470	1620	***43.6***	1300	21.5	36.0
NB-AVN	10.0-11.0	29500	27.0	8030	1380	***43.0***	1200	20.7	26.3
NB-AVN	22.0-23.0	28900	25.8	8100	780	***42.4***	1070	20.5	28.8
AVN-UP	0.0-1.0	31800	29.6	8790	1690	***45.3***	1300	22.7	37.2
AVN-UP	8.0-9.0	23400	21.7	6850	805	***37.6***	809	14.1	21.3
AVN-UP	17.0-18.0	23900	21.5	6960	755	***38.8***	856	15.0	18.3

CCME ISQG is Interim Sediment Quality Guideline (ISQG). PEL is Probable Effects Level (CCME or NOAA SQuiRT). TEL is Threshold Effects Level (NOAA SQuiRT). SQG is the Soil Quality Guideline for agricultural use. Samples and guidelines are in mg/kg-dry weight except for THg which is µg/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples are < DLs, data are reported as a range. aCCME Guideline (CCME, 1998-2001; CCME, 1991-2009). bSQuiRT Guideline (Buchman, 2008).

Table 8 (continued): Metals and other elements in Snowshoe Island, Bear Island, NB-AVN and AVN-UP sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL. Results highlighted in red are above the CCME SQG for agricultural use.

Depth (cm)	Depth	S	Se	Sr	Tl	U	V	Zn
Units	cm	(mg/kg-dwkg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)	(mg/kg-dw)
ISQG or TEL					-		-	123[b]
PEL					-		-	315[b]
SQG					1[a]		130[a]	200[a]
Snowshoe Island	0.0-1.0	573	<DL	38.2	1.10	<DL	43.9	100
Snowshoe Island	1.0-2.0	549	<DL	35.9	0.65	<DL	45.8	96.4
Snowshoe Island	6.0-7.0	1290	<DL	32.5	<DL	<DL	50.8	106
Snowshoe Island	11.0-12.0	707	<DL	20.5	<DL	<DL	32.9	52.2
Bear Island	0.0-1.0	669	<DL	37.0	<DL	<DL	41.4	85.5
Bear Island	9.0-10.0	755	<DL	30.2	<DL	<DL	41.0	87.7
Bear Island	18.0-19.0	910	<DL	30.9	<DL	<DL	38.1	88.3
NB-AVN	0.0-1.0	834	<DL	37.2	0.58	<DL	38.6	78.3
NB-AVN	10.0-11.0	705	<DL	38.5	<DL	<DL	33.1	73.4
NB-AVN	22.0-23.0	1160	<DL	29.3	<DL	<DL	35.2	75.8
AVN-UP	0.0-1.0	851	<DL	45.6	<DL	<DL	40.1	79.4
AVN-UP	8.0-9.0	491	<DL	28.5	<DL	<DL	24.3	44.2
AVN-UP	17.0-18.0	508	<DL	26.9	<DL	<DL	22.3	51.4

CCME ISQG is Interim Sediment Quality Guideline (ISQG). PEL is Probable Effects Level (CCME or NOAA SQuiRT). TEL is Threshold Effects Level (NOAA SQuiRT). SQG is the Soil Quality Guideline for agricultural use. Samples and guidelines are in mg/kg-dry weight except for THg which is µg/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples are < DLs, data are reported as a range. [a]CCME Guideline (CCME, 1998-2001; CCME, 1991-2009). [b]SQuiRT Guideline (Buchman, 2008).

Headpond Core Samples

Metals and elements that were analyzed in the core samples are listed in Table 6 for Long Creek, Table 7 for Riverside and Table 8 for the Snowshoe Island, Bear Island, NB-AVN and AVN-UP core sites. Across all metals and elements, iron and aluminum were found at the highest concentrations (23400 mg/kg-dw at AVN-UP to 42900 mg/kg-dw at Riverside for iron and 16700 mg/kg-dw at AVN-UP to 41800 mg/kg-dw at Riverside) and total mercury was at the lowest concentrations (36.0 µg/kg-dw at Snowshoe Island to 131 µg/kg-dw at Riverside) in the core slices (Tables 6, 7 and 8). Silver was not detected in any of the core samples sites (not included in this report).

Long Creek Core

Iron ranged from 30900 to 40000 mg/kg-dw throughout the core. The highest concentration was found in the 1.0-1.5 cm section and the lowest was found near the bottom at 7.0-7.5 cm. Total mercury within the core ranged from 106 to 117 µg/kg-dw. Aluminium, arsenic, cobalt, chromium, copper, lanthanum, magnesium, manganese, nickel, lead, rubidium, sulphur, selenium, strontium, thallium, vanadium and zinc were present in the Long Creek core slices above DLs. Uranium was detected in the six slices between 2.5-5.5 cm depth. With a few exceptions (e.g. copper at slice 2.5-3.0 cm), concentrations of most elements were similar through the core.

Nickel was above PEL for all slices of the Long Creek core (Table 6) and at or just above the SQG from 2.5 to 4.0 cm. The slices were also all above ISQG for arsenic and chromium. Thallium was greater than the SQG for all depths except for 7.0-7.5 cm. Copper exceeded the ISQG at 2.0-2.5 cm.

Riverside Core

The Riverside core slices had iron concentrations ranging from 30200 to 42900 mg/kg-dw in the slices from 0.0-8.5 cm and 24.0-30 cm (Table 7). Similar to the Long Creek core, the highest concentrations were found in top section of the core (0.0-0.5 cm) and the lowest concentration was found in lowest slice 28.5-29.0 cm. Total Hg concentrations in Riverside ranged from 89 (1.0-1.5 cm) to 131 (28.0-28.5 cm) µg/kg-dw. Arsenic, cobalt, chromium, copper, lanthanum, magnesium, manganese, nickel, phosphorous, rubidium, sulphur, strontium, vanadium and zinc were found at all depths. Of all elements, iron, arsenic, manganese, magnesium, selenium, thallium, and phosphorous tended to be higher in the surface slices than the deeper slices. Lead tended to have higher concentrations in deeper slices. Cadmium was detected at several depths throughout the core, with a maximum concentration of 0.28 mg/kg-dw. Uranium was detected only in the 6.0-6.5 cm slice within this core.

Nickel was consistently above the PEL at all depths and above the SQG for 14 of the 29 slices. Arsenic and chromium were above the ISQG in all slices. For arsenic, 4 slices were above the PELs and 9 slices exceeded SQG; these exceedances were only in the surface slices. Chromium exceeded the SQG only at the 7.0 to 7.5 cm depth. Lead exceeded the ISQG for the bottom 1 cm of the core. Thallium was above SQG for 17 of the 29 slices tested.

Snowshoe Island, Bear Island, NB-AVN and AVN UP Cores

In the cores from Snowshoe Island, Bear Island, NB-AVN and AVN-UP, iron concentrations ranged of 26400-42500 mg/kg-dw, 30200 to 35900 mg/kg-dw, 28900 to 32700 mg/kg-dw and 23400 to 31800 mg/kg-dw, respectively (Table 8). The lowest concentrations were found in the deepest slice tested whereas the highest concentration was found in the first 1-2 cm at all 4 sites. THg concentration ranges were as follows: Snowshoe Island ranged from 36.0 to 106 µg/kg-dw, Bear Island from 86.1 to 97.9 µg/kg-dw, NB-AVN from 66.6 to 83.2 µg/kg-dw and AVN-UP from 40.8 to 76.8 µg/kg-dw. Thallium was found in the top 2.0 cm of Snowshoe Island and the top 1.0 cm of NB-AVN. Cadmium was greater than the DLs in Snowshoe Island (0.0-2.0 and 6.0-7.0 cm), Bear Island at 18.0-19.0 cm, NB-AVN for all slices and AVN-UP from 0.0-1.0 cm. All other metals (arsenic, cobalt, chromium, copper, lanthanum, magnesium, manganese, nickel, phosphorous, lead, rubidium, sulphur, strontium, vanadium and zinc) were detected at each site for all slices. The trend of higher concentrations in surface slices than the deepest slice was also seen for manganese (Snowshoe, Bear Island, NB-AVN and AVN-UP), magnesium (Snowshoe, Bear Island, NB-AVN and AVN-UP), nickel (Snowshoe), phosphorous (Snowshoe, AVN-UP), lead (Snowshoe, AVN-UP), rubidium, strontium, vanadium, and zinc (Snowshoe, AVN-UP), though sample sizes for these cores were limited. Where selenium and uranium which were <DLs at all depths tested.

Nickel was above the PEL for all Snowshoe Island, Bear Island, NB-AVN and AVN-UP slices tested. Snowshoe Island was above the Ni ISQG at depths of 0.0-1.0, 1.0-2.0 and 6.0-7.0 cm. Arsenic was above the ISQG for 3 of 4 core slices at Snowshoe Island, all of the slices for Bear Island and NB-AVN, and the top slice of AVN-UP. The arsenic SQG was exceeded for the 0.0-2.0 cm slices at Snowshoe Island and between 0.0-1.0 cm at Bear Island. Chromium was above the ISQG for Snowshoe Island, Bear Island and NB-AVN at all depths. AVN-UP exceeded the ISQG for chromium only at 0.0-1.0 cm. Bear Island core samples were above the ISQG for copper in the 9.0-10.0 cm slice. Thallium was above the SQG for the top 1.0 cm of the Snowshoe Island core.

Table 9: Polycyclic aromatic hydrocarbons (mg/kg-dry weight) in surface sediment samples collected in 2015 from the headpond and downstream sites and reference lakes (see Figure 1). Sites are listed from upstream to downstream in the headpond. Bolded numbers are above the CCME ISQG or NOAA SQuiRT TEL. Bolded and italicized numbers are above the CCME or NOAA SQuiRT PEL.

Site # or Guideline Value	n	Naphthalene	Acenaphthylene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene
ISQG or TEL			0.006[a]	0.021[a]	0.042[a]	0.047[a]	0.11[a]	0.053[a]	0.032[a]
PEL			0.13[a]	0.14[a]	0.52[a]	0.25[a]	2.36[a]	0.88[a]	0.39[a]
Site 31	5	0.013 ± 0.001	**<DL-0.011**	0.011 ± 0.004	**0.060 ± 0.022**	0.016 ± 0.008	0.064 ± 0.013	**0.067 ± 0.014**	0.022 ± 0.004
Site 2	5	<DL	**0.010 ± 0.003**	0.012 ± 0.003	**0.051 ± 0.011**	0.021 ± 0.001	0.054 ± 0.011	0.051 ± 0.009	0.024 ± 0.006
Site 29	5	0.016 ± 0.006	**0.011 ± 0.007**	<DL-0.027	**0.181 ± 0.087**	0.026 ± 0.013	**0.123 ± 0.027**	**0.136 ± 0.043**	**0.047 ± 0.005**
Site 28	5	<DL-0.13	**0.027 ± 0.022**	**0.031 ± 0.032**	**0.129 ± 0.074**	0.031 ± 0.013	0.089 ± 0.015	**0.091 ± 0.023**	**0.047 ± 0.004**
Site 26	5	<DL	**0.011 ± 0.007**	0.011 ± 0.004	**0.053 ± 0.020**	0.016 ± 0.005	0.056 ± 0.005	0.051 ± 0.006	**0.032 ± 0.002**
Site 27	5	<DL	**0.017 ± 0.001**	0.012 ± 0.002	0.041 ± 0.010	0.018 ± 0.002	0.063 ± 0.006	**0.057 ± 0.007**	**0.039 ± 0.003**
Site 16	5	<DL-0.02	**0.012 ± 0.001**	<DL-0.020	**0.172 ± 0.105**	0.024 ± 0.013	0.094 ± 0.027	**0.103 ± 0.043**	0.029 ± 0.003
Site 14	5	<DL	**<DL-0.010**	**<DL-0.030**	**0.125 ± 0.062**	0.029 ± 0.006	0.074 ± 0.010	**0.077 ± 0.014**	0.026 ± 0.002
Site 25	5	0.028 ± 0.003	<DL	0.019 ± 0.002	**0.058 ± 0.015**	0.022 ± 0.001	0.035 ± 0.003	0.035 ± 0.004	<DL
Site 32	5	0.017 ± 0.013	<DL	0.015 ± 0.013	**0.095 ± 0.082**	0.032 ± 0.017	0.096 ± 0.060	**0.099 ± 0.061**	0.031 ± 0.018
Site 33	5	<DL	<DL	<DL	**0.083 ± 0.070**	<DL-0.016	0.038 ± 0.015	0.044 ± 0.019	<DL
Site 34 – ref	5	0.024 ± 0.004	**0.014 ± 0.007**	<DL	***0.520 ± 0.247***	**0.059 ± 0.029**	**0.238 ± 0.095**	**0.276 ± 0.147**	**0.060 ± 0.010**
Site 35 – ref	5	0.020 ± 0.012	**<DL-0.010**	**0.027 ± 0.025**	**0.288 ± 0.162**	**0.047 ± 0.029**	**0.119 ± 0.062**	**0.165 ± 0.117**	0.020 ± 0.014
Site 36 – ref	5	0.049 ± 0.016	**0.028 ± 0.005**	**0.037 ± 0.032**	**0.503 ± 0.240**	**0.075 ± 0.022**	**0.267 ± 0.070**	**0.290 ± 0.113**	**0.067 ± 0.017**
Site 38 – ref	5	0.037 ± 0.010	**0.019 ± 0.005**	**0.023 ± 0.015**	**0.189 ± 0.097**	0.035 ± 0.017	**0.143 ± 0.055**	**0.128 ± 0.064**	**0.046 ± 0.010**

CCME ISQG is Interim Sediment Quality Guideline. PEL is Probable Effects Level (CCME or SQuiRT Tables). TEL is Threshold Effects Level (SQuiRT Tables). Samples and guidelines are in mg/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples are < DLs, data are reported as a range.
[a]CCME Guideline (CCME, 1998-2001; CCME, 1991-2009). [b]SQuiRT Guideline (Buchman, 2008**)**.

Table 9 (continued): Polycyclic aromatic hydrocarbons (mg/kg-dry weight) in surface sediment samples collected in 2015 from the headpond and downstream sites and reference lakes (see Figure 1). Sites are listed from upstream to downstream in the headpond. Bolded numbers are above the CCME ISQG or NOAA SQuiRT TEL. Bolded and italicized numbers are above the CCME or NOAA SQuiRT PEL

Site # or Guideline Value	N	Chrysene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Benzo(g,h,i)perylene	TPAHs
ISQG or TEL		0.057[a]			0.032a			1.61b
PEL		0.86[a]			0.78a			
Site 31	5	0.024 ± 0.005	<DL	<DL	<DL	0.013 ± 0.006	0.017 ± 0.009	0.312 ± 0.087
Site 2	5	<DL	<DL-0.016	<DL	<DL	0.019 ± 0.010	0.022 ± 0.007	0.264 ± 0.056
Site 29	5	0.050 ± 0.006	<DL	<DL	<DL	0.022 ± 0.019	0.025 ± 0.020	0.660 ± 0.167
Site 28	5	0.031 ± 0.004	<DL	<DL	<DL	0.053 ± 0.004	0.027 ± 0.003	0.603 ± 0.273
Site 26	5	0.012 ± 0.006	<DL	<DL	<DL	0.027 ± 0.021	0.017 ± 0.006	0.282 ± 0.075
Site 27	5	0.022 ± 0.002	<DL	<DL	<DL	<DL-0.050	0.025 ± 0.002	0.304 ± 0.046
Site 16	5	0.036 ± 0.004	<DL	<DL	<DL	<DL-0.039	0.022 ± 0.013	0.510 ± 0.169
Site 14	5	<DL	<DL	<DL	<DL	0.020 ± 0.015	0.031 ± 0.001	0.398 ± 0.099
Site 25	5	<DL	<DL	<DL	<DL	<DL	<DL	0.201 ± 0.018
Site 32	5	0.043 ± 0.018	0.044 ± 0.024	0.030 ± 0.016	<DL	0.037 ± 0.017	0.034 ± 0.012	0.573 ± 0.339
Site 33	5	<DL	<DL	<DL	<DL	<DL	<DL	0.167 ± 0.102
Site 34 – ref	5	**0.084 ± 0.011**	<DL	<DL	<DL	0.088 ± 0.020	0.075 ± 0.015	1.44 ± 0.52
Site 35 – ref	5	0.041 ± 0.023	<DL	<DL	<DL	0.047 ± 0.030	0.044 ± 0.025	0.819 ± 0.427
Site 36 – ref	5	**0.089 ± 0.019**	<DL	<DL	<DL	0.106 ± 0.027	0.092 ± 0.017	**1.61 ± 0.49**
Site 38 – ref	5	**0.065 ± 0.010**	<DL	<DL	<DL	0.080 ± 0.013	0.062 ± 0.037	0.827 ± 0.304

CCME ISQG is Interim Sediment Quality Guideline. PEL is Probable Effects Level (CCME or SQuiRT Tables). TEL is Threshold Effects Level (SQuiRT Tables). Samples and guidelines are in mg/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples are < DLs, data are reported as a range. [a]CCME Guideline (CCME, 1998-2001; CCME, 1991-2009). [b]SQuiRT Guideline (Buchman, 2008).

Polycyclic Aromatic Hydrocarbons (PAHs)

Headpond and Downstream Surface Sediments

Of the 16 individual PAHs measured in sediments, acenaphthene, benzo(a)pyrene and dibenz(ah)anthracene were below detection limits for all sites, except for one replicate for acenaphthene at site 28 (n=5). Acenaphthene and dibenz(a,h)anthracene are not listed in Table 9. The remaining 12 PAHs were found in sediments from at least one site. 3 PAHs were detected at 1 or 2 sites; benz(a)anthracene (sites 25 and 33), benzo(b)fluoranthene (sites 2 and 35) and benzo(k)fluoranthene (site 35). Acenaphthylene was detected in 8 sites, with a maximum of 0.027 mg/kg-dw at site 28. Fluorene was detected at all sites except site 33, whereas indeno(1,2,3-cd)pyrene and benzo(g,h,i)perylene were at concentrations greater than the detection limits for all sites except 25 and 33. Naphthalene and chrysene were detected at 6 and 7 sites, respectively. Phenanthrene, fluoranthene, anthracene and pyrene were found at all locations tested (up to 10x higher than other individual PAH concentrations). The PAHs with the highest concentrations were phenanthrene (0.041 to 0.181 mg/kg-dw) and pyrene (means of 0.035 to 0.136 mg/kg-dw; Table 9). The mean concentrations of total PAHs ranged from 0.167 mg/kg-dw at site 33 to 0.660 mg/kg-dw at site 29.

Sediment quality guidelines were exceeded whenever acenaphthylene was detected (at 7 sites). Exceedances were also found for fluorene (sites 28 and 14), fluoranthene (site 29), benz(a)anthracene (sites 26-29), phenanthrene (all sites except 27) and pyrene (all sites except 2, 25, 26 and 33). Total PAHs and 6 other individual PAHs did not exceed TEL or ISQGs at any of the sites (Table 9).

Total PAHs were ranked for all headpond sites and the highest ranked sites were 16, 27, 26 and 14 whereas the lowest ranked sites were 33, 02, 31 and 32.

A few individual PAHs were generally found at higher concentrations in 2015 samples than those collected in 2014 and include: benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, acenaphthylene, and phenanthrene.

Reference Lake Surface Sediments

The four reference lakes (sites 34, 35, 36 and 38) were below DLs for benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene and acenaphthene. Dibenz(ah)anthracene was <DL at all sites except for 1 replicate at site 34. All sites contained fluorene, except site 34. The remaining 10 PAHs (naphthalene, acenaphthylene, phenanthrene, anthracene, fluoranthene, pyrene, benz(a)anthracene, chrysene, indeno(1,2,3-cd)pyrene and benzo(g,h,i)perylene were found in surface sediments from all four reference lakes (Table 9). Of all the detectable PAHs, phenanthrene (0.189 to 0.520 mg/kg-dw) and pyrene (0.128 to 0.276 mg/kg-dw) were present at the highest concentrations and were 2-5 times higher than the concentrations found in the headpond.

ISQGs were exceeded for acenaphthylene, phenanthrene, pyrene and fluoranthene at all sites. All sites but one exceeded the ISQG for fluorene (site 34), anthracene (site 38), benz(a)anthracene (site 35) and chrysene (site 35). Total PAHs were above the ISQG at one site (36) at 1.61 mg/kg-dw. All reference sites exceeded concentrations of TPAHs found in the headpond by up to 10 fold.

Total PAHs were ranked and compared across the headpond and reference sites. The highest ranked sites were 32, 38, 34 and 36, three of which were reference sites. The remaining reference lake (35) fell within the headpond sites. This indicates that the reference sites typically had higher concentrations of total PAHs than most of the headpond locations.

Table 10: Polycyclic aromatic hydrocarbons (mg/kg-dry weight) in Long Creek and Riverside sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL.

Site # or Guideline Value	Depth (cm)	Naphthalene	Acenaphthylene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene
ISQG or TEL			0.006[a]	0.021[a]	0.042[a]	0.047[a]	0.11[a]	0.053[a]	0.032[a]
PEL			0.13[a]	0.14[a]	0.52[a]	0.25[a]	2.36[a]	0.88[a]	0.39[a]
Long Creek	0.0-2.0	<DL	<DL	<DL	0.041	0.010	0.085	**0.069**	**0.032**
Long Creek	2.0-3.0	<DL	<DL	<DL	**0.042**	<DL	0.091	**0.076**	**0.036**
Long Creek	3.0-4.0	<DL	<DL	<DL	**0.042**	0.012	0.091	**0.075**	**0.036**
Long Creek	4.0-5.0	<DL	<DL	<DL	0.038	<DL	0.088	**0.071**	**0.035**
Long Creek	5.0-6.0	<DL	<DL	<DL	0.042	<DL	0.098	**0.086**	**0.042**
Long Creek	6.0-7.0	0.010	**0.010**	<DL	0.039	0.011	0.093	**0.082**	**0.035**
Long Creek	7.0-8.0	<DL	**0.012**	<DL	**0.044**	0.014	**0.109**	**0.100**	**0.047**
Riverside	0.0-2.0	<DL	<DL	<DL	0.028	<DL	0.054	0.049	0.023
Riverside	2.0-4.0	<DL	<DL	<DL	0.024	<DL	0.049	0.042	0.020
Riverside	4.0-5.5	<DL	<DL	<DL	0.027	<DL	0.061	**0.054**	0.024
Riverside	5.5-7.0	<DL	<DL	<DL	0.031	<DL	0.052	0.043	<DL
Riverside	7.0-8.5	<DL	<DL	<DL	0.025	<DL	0.048	0.040	0.018
Riverside	24.0-25.5	0.030	**0.011**	<DL	0.036	<DL	**0.116**	**0.100**	**0.040**
Riverside	25.5-26.5	<DL	<DL	<DL	**0.053**	<DL	**0.120**	**0.107**	**0.047**
Riverside	26.5-27.5	0.011	**0.014**	<DL	**0.058**	0.011	**0.129**	**0.109**	**0.058**
Riverside	27.5-28.5	<DL	<DL	<DL	**0.064**	<DL	**0.150**	**0.136**	**0.064**
Riverside	28.5-30.0	0.010	**0.015**	<DL	**0.064**	0.018	**0.147**	**0.133**	**0.061**

CCME ISQG is Interim Sediment Quality Guideline. PEL is Probable Effects Level (CCME or SQuiRT Tables). TEL is Threshold Effects Level (SQuiRT Tables). Samples and guidelines are in mg/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples are < DLs, data are reported as a range. [a]CCME Guideline (CCME, 1998-2001; CCME, 1991-2009). [b]SQuiRT Guideline (Buchman, 2008).

Table 10 (continued): Polycyclic aromatic hydrocarbons (mg/kg-dry weight) in Long Creek and Riverside sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL.

Site # or Guideline Value	**Depth (cm)**	**Chrysene**	**Benzo(b)fluoranthene**	**Benzo(k) fluoranthene**	**Benzo(a)pyrene**	**Indeno(1,2,3-cd)pyrene**	**Dibenz(a,h)anthracene**	**Benzo(g,h,i)perylene**	**TPAHs**
ISQG or TEL		0.057[a]			0.032a				1.61b
PEL		0.86[a]			0.78a				
Long Creek	0.0-2.0	**0.064**	<DL	<DL	<DL	<DL	<DL	0.038	0.339
Long Creek	2.0-3.0	**0.072**	<DL	<DL	<DL	0.047	<DL	0.043	0.407
Long Creek	3.0-4.0	**0.071**	<DL	<DL	<DL	0.044	<DL	0.042	0.414
Long Creek	4.0-5.0	**0.068**	<DL	<DL	<DL	0.045	<DL	0.043	0.389
Long Creek	5.0-6.0	**0.070**	<DL	<DL	<DL	0.054	<DL	0.051	0.465
Long Creek	6.0-7.0	**0.071**	<DL	<DL	<DL	0.050	<DL	0.045	0.445
Long Creek	7.0-8.0	**0.085**	<DL	<DL	<DL	0.057	<DL	0.054	0.521
Riverside	0.0-2.0	0.037	<DL	<DL	<DL	0.030	<DL	0.030	0.25
Riverside	2.0-4.0	0.036	<DL	<DL	<DL	0.029	<DL	0.029	0.23
Riverside	4.0-5.5	0.049	<DL	<DL	<DL	0.032	<DL	0.034	0.28
Riverside	5.5-7.0	0.040	<DL	<DL	<DL	<DL	<DL	0.028	0.19
Riverside	7.0-8.5	0.036	<DL	<DL	<DL	0.023	<DL	0.023	0.21
Riverside	24.0-25.5	**0.065**	<DL	<DL	<DL	<DL	<DL	0.044	0.44
Riverside	25.5-26.5	**0.091**	<DL	<DL	<DL	0.067	<DL	0.061	0.55
Riverside	26.5-27.5	**0.112**	<DL	<DL	<DL	0.074	<DL	0.067	0.64
Riverside	27.5-28.5	**0.111**	<DL	<DL	<DL	0.084	<DL	0.078	0.69
Riverside	28.5-30.0	**0.113**	<DL	<DL	<DL	0.085	<DL	0.084	0.73

CCME ISQG is Interim Sediment Quality Guideline. PEL is Probable Effects Level (CCME or SQuiRT Tables). TEL is Threshold Effects Level (SQuiRT Tables). Samples and guidelines are in mg/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples are < DLs, data are reported as a range.
[a]CCME Guideline (CCME, 1998-2001; CCME, 1991-2009). [b]SQuiRT Guideline (Buchman, 2008).

Table 11: Polycyclic aromatic hydrocarbons (mg/kg-dry weight) in Snowshoe Island, Bear Island, NB-AVN and AVN-UP sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL.

Site # or Guideline Value	Depth	Naphthalene	Acenaphthylene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene
ISQG or TEL			0.006[a]	0.021[a]	0.042[a]	0.047[a]	0.11[a]	0.053[a]	0.032[a]
PEL			0.13[a]	0.14[a]	0.52[a]	0.25[a]	2.36[a]	0.88[a]	0.39[a]
Snowshoe Island	0.0-2.0	<DL	<DL	<DL	<DL	<DL	0.012	0.011	<DL
Snowshoe Island	6.0-7.0	0.011	<DL	<DL	0.039	<DL	0.082	**0.072**	0.028
Snowshoe Island	11.0-12.0	<DL	<DL	<DL	0.020	<DL	0.040	0.036	0.013
Bear Island	0.0-1.0	<DL	<DL	<DL	0.035	<DL	0.075	**0.065**	0.028
Bear Island	9.0-10.0	<DL	<DL	<DL	**0.055**	0.013	**0.119**	**0.097**	**0.038**
Bear Island	18.0-19.0	0.015	**0.018**	0.011	**0.113**	0.028	**0.252**	**0.220**	**0.087**
NB-AVN	0.0-1.0	0.012	<DL	<DL	0.034	<DL	0.069	**0.064**	0.028
NB-AVN	10.0-11.0	<DL	<DL	<DL	0.040	<DL	0.090	**0.080**	**0.033**
NB-AVN	22.0-23.0	<DL	<DL	<DL	0.030	<DL	0.060	0.052	0.023
AVN-UP	0.0-1.0	0.012	<DL	<DL	0.040	<DL	0.070	**0.063**	0.028
AVN-UP	8.0-9.0	<DL	<DL	<DL	0.034	<DL	0.064	**0.058**	0.026
AVN-UP	17.0-18.0	<DL	<DL	<DL	0.030	<DL	0.057	0.047	0.021

CCME ISQG is Interim Sediment Quality Guideline. PEL is Probable Effects Level (CCME or SQuiRT Tables). TEL is Threshold Effects Level (SQuiRT Tables). Samples and guidelines are in mg/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples are < DLs, data are reported as a range.
[a]CCME Guideline (CCME, 1998-2001; CCME, 1991-2009). [b]SQuiRT Guideline (Buchman, 2008).

Table 11 (continued): Polycyclic aromatic hydrocarbons (mg/kg-dry weight) in Snowshoe Island, Bear Island, NB-AVN and AVN-UP sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG or SQuiRT TEL. Bolded and italicized numbers are above the CCME or SQuiRT PEL.

Site # or Guideline Value	Depth	Chrysene	Benzo(b)fluoranthene	Benzo(k) fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenz_ah_anthracene	Benzo(g,h,i)perylene	TPAHs
ISQG or TEL		0.057[a]			0.032a				1.61b
PEL		0.86[a]			0.78a				
Snowshoe Island	0.0-2.0	<DL	<DL	<DL	<DL	<DL	<DL	<DL	0.023
Snowshoe Island	6.0-7.0	**0.057**	<DL	<DL	<DL	0.046	<DL	0.033	0.369
Snowshoe Island	11.0-12.0	0.027	<DL	<DL	<DL	0.016	<DL	0.014	0.165
Bear Island	0.0-1.0	0.045	<DL	<DL	<DL	0.033	<DL	<DL	0.280
Bear Island	9.0-10.0	**0.064**	<DL	<DL	<DL	0.049	<DL	0.040	0.474
Bear Island	18.0-19.0	**0.134**	0.119	0.122	**0.101**	0.104	0.019	0.086	1.43
NB-AVN	0.0-1.0	0.041	<DL	<DL	<DL	0.034	<DL	0.025	0.293
NB-AVN	10.0-11.0	0.054	<DL	<DL	<DL	0.040	<DL	0.031	0.368
NB-AVN	22.0-23.0	0.036	<DL	<DL	<DL	0.027	<DL	0.020	0.248
AVN-UP	0.0-1.0	0.044	<DL	<DL	<DL	0.033	<DL	0.030	0.307
AVN-UP	8.0-9.0	0.036	<DL	<DL	<DL	0.024	<DL	0.020	0.262
AVN-UP	17.0-18.0	0.032	<DL	<DL	<DL	0.021	<DL	0.019	0.228

CCME ISQG is Interim Sediment Quality Guideline. PEL is Probable Effects Level (CCME or SQuiRT Tables). TEL is Threshold Effects Level (SQuiRT Tables). Samples and guidelines are in mg/kg-dry weight. Average ± Standard Deviation is reported for sites with n=5. When some samples are < DLs, data are reported as a range. [a]CCME Guideline (CCME, 1998-2001; CCME, 1991-2009). [b]SQuiRT Guideline (Buchman, 2008).

Headpond Sediment Cores

Across all of the sediment core samples collected in February and June of 2016, the TPAHs range from 0.165 to 1.43 mg/kg-dw (Table 10 and Table 11). Acenapthalene was not detected in any core and is not shown. In all slices, fluoranthene and pyrene were the largest contributors to the TPAH concentrations.

Long Creek Core

Fluorene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene and dibenz(a,h)anthracene were not detected (<DL) in any core slices. Naphthalene was detected at 6.0-7.0 cm whereas acenaphthylene was detected from 6.0-8.0 cm (bottom 2 slices) and ranged from 0.010-0.012 mg/kg-dw. Anthracene was detected at 0.0-2.0, 3.0-4.0, 6.0-8.0 cm. Indeno(1,2,3-cd)pyrene was found from 2.0-8.0 cm of this core. Phenanthrene, fluoranthene, pyrene, benz(a)anthracene, chrysene, and benzo(g,h,i)perylene were found at all depths (Table 10). The highest concentrations of individual PAHs were for fluoranthene and pyrene, ranging from 0.085 to 0.109 and 0.069 to 0.100 mg/kg-dw, respectively. Total PAHs and many individual compounds showed higher concentrations in the lower slices of the core when compared to the slices closer to the surface.

CCME ISQG exceedances were found for acenaphthylene, pyrene, benz(a)anthracene and chrysene at all depths where they were detected. Fluoranthene only exceeded ISQG guidelines at the 7.0-8.0 cm depth whereas phenanthrene was above guidelines at depths of both 2.0-4.0 cm and 7.0-8.0 cm. TPAHs never exceeded the 1.61 mg/kg-dw ISQG. No PELs for individual PAHs were exceeded at the Long Creek site.

Riverside Core

Similar to the Long Creek core, Riverside slices were also below detection limits for fluorene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene and dibenz(a,h)anthracene at all depths tested (0.0-8.5 cm and 24.0-30.0 cm). Both naphthalene and acenaphthylene were >DL at 24.0-25.5, 26.5-27.5 and 28.5-30.0 cm depths. Anthracene was also found at 26.5-27.5 and 28.5-30.0 cm depths. Benz(a)anthracene was found at all depths except for 5.5-7.0 cm. Indeno(1,2,3-cd)pyrene was detected at all depths except for 5.5-7.0 cm and 24.0-25.5 cm. The remaining 5 PAHs (phenanthrene, fluoranthene, pyrene, chrysene and benzo(g,h,i)perylene were detected at all depths in this core (Table 10). Similar to Long Creek, fluoranthene and pyrene were the most dominant PAHs present at 0.048 to 0.150 and 0.040 to 0.136 mg/kg-dw respectively. As above, total PAHs and several individual PAHs were at greater concentrations in the deeper slices of this core than those in the surface layers.

Acenaphthylene was greater than the ISQG for 3 of the deeper slices only. Phenanthrene, fluoranthene, pyrene, benz(a)anthracene and chrysene had 4-6 slices above the ISQG and most of them were also in the deeper depths of the core (24.0-30.0 cm); pyrene was also above the ISQG at 4.0-5.5 cm. As for the Long Creek core, no PELs were exceeded in the Riverside core.

Snowshoe Island Core

Snowshoe Island had measurable concentrations (Table 11) of phenanthrene, indeno(1,2,3-cd)pyrene, benz(a)anthracene and benzo(g,h,i)perylene at 6.0-7.0 and 11.0-12.0 cm. Acenaphthylene, fluorene, anthracene, benzo(b)fluoranthene, benzo(b)fluoranthene, benzo(a)pyrene and dibenz(a,h)anthracene were not detectable in all 3 depths tested (0.0-2.0, 6.0-7.0 and 11.0-12.0 cm). Naphthalene was only found at 6.0-7.0 cm at 0.011 mg/kg-dw. The highest PAH concentrations at this site were fluoranthene (0.012-0.082 mg/kg-dw) and pyrene (0.011-0.072 mg/kg-dw). The highest concentrations of total PAHs and individual PAHs tended to be in the middle slice.

Unlike Long Creek and Riverside, pyrene and chrysene were the only PAHs that were greater than the ISQGs at Snowshoe Island; both compounds exceeded the guideline at depths of 6.0-7.0 cm. TPAHs never exceeded guidelines for Snowshoe Island.

Bear Island Core

At 18.0-19.0 cm, naphthalene, acenaphthylene, fluorene, benzo(b)fluoranthene, benzo(b)fluoranthene, benzo(a)pyrene and dibenz(a,h)anthracene were detected (Table 11). Similarly, anthracene and benzo(g,h.i)perylene were found in 2 of the slices tested (9.0-10.0 and 18.0-19.0 cm). The remaining 6 PAHs were found at all depths of the Bear Island core. Like the other core samples, fluoranthene and pyrene were the individual PAHs present at the highest concentrations (0.075 to 0.252 and 0.065-0.220 mg/kg-dw). As was observed for the Riverside and Long Creek cores, the deepest slice in the Bear Island core had the highest concentrations of these contaminants.

Sediment guidelines were exceeded for phenanthrene, fluoranthene, benz(a)anthracene and chrysene at both 9.0-10.0 and 18.0-19.0 cm. Pyrene was greater than ISQG for all depths tested at Bear Island. Only the 18.0-19.0 cm section was above ISQG for acenaphthylene and benzo(a)pyrene.

NB-AVN Core

The NB-AVN (upstream) core is identical to the Snowshoe Island site in that acenaphthylene, fluorene, anthracene, benzo(b)fluoranthene, benzo(b)fluoranthene, benzo(a)pyrene and dibenz(a,h)anthracene were less than DLs at all depths analyzed. Naphthalene was only detected in the top 1.0 cm of the core. All remaining PAHs (phenanthrene, fluoranthene, pyrene, benz(a)anthracene, chrysene, Indeno(1,2,3-cd)pyrene and benzo(g,h,i)perylene) were detected in each slice of the NB-AVN core (Table 11). As previously, individual PAHs at the highest concentrations were fluoranthene (0.075 to 0.252 mg/kg-dw) and pyrene (0.064 to 0.080 mg/kg-dw) in this core. In this core, the middle depth (10.0-11.0 cm tended to have the highest concentrations of both total and individual PAHs.

ISQG were exceeded for 2 PAHs: pyrene (0.0-1.0 and 10.0-11.0 cm) and benz(a)anthracene (10.0-11.0 cm). No PELs were exceeded for individual PAHs or TPAHs at NB-AVN for all depths.

AVN-UP Core

As seen for the above cores, the AVN-UP site was found to be lower than detection limits for: acenaphthylene, fluorene, anthracene, benzo(b)fluoranthene, benzo(b)fluoranthene, benzo(a)pyrene and dibenz(a,h)anthracene at the 3 depths tested (0.0-1.0, 8.0-9.0 and 17.0-18.0 cm). AVN-UP is the same as NB-AVN with naphthalene detected in the 0.0-1.0 cm layer and the remaining PAHs present in all layers processed. Like all other cores tested, fluoranthene and pyrene had the highest concentrations of all individual PAHs and were present at 0.057 to 0.070 and 0.047 to 0.063 mg/kg-dw, respectively (Table 11), throughout the AVN-UP core. In contrast to other cores, individual PAHs and total PAH tended to be present at higher concentrations in the surface slice than deeper slices.

ISQG guidelines were exceeded for pyrene at 0.0-1.0 cm and 8.0-9.0 cm within the AVN-UP core. No other PAH exceeded guidelines (ISQG or PEL) in the AVN-UP core.

Table 12: Chlorinated pesticides (μg/kg dry weight) in surface sediment samples collected from the headpond and downstream sites and reference lakes in 2015 (see Figure 1 for locations; see Table 15 for guideline exceedances). Sites are listed from upstream to downstream in the headpond.

Site #	n	Hexachlorobenzene	Aldrin	Dieldrin	Methoxychlor	Σ HCHs	Σ Heptachlor	Σ Chlordane	Σ Nonachlor	Σ DDTs	Σ Endosulfan	Σ Endrin
Site 31	5	<DL	<DL	<DL	<DL-0.49	<DL-0.13	<DL	<DL-0.16	<DL	7.50 ± 4.50	0.38 ± 0.14	<DL
Site 2	5	<DL	<DL	<DL	2.09 ± 1.09	<DL-0.18	<DL	<DL	<DL	3.62 ± 1.52	0.22 ± 0.18	<DL
Site 29	5	<DL	<DL	<DL-0.15	<DL-0.30	0.21 ± 0.17	<DL-0.24	0.34 ± 0.19	<DL-0.26	34.5 ± 12.3	1.74 ± 0.52	0.48 ± 0.21
Site 28	5	<DL-0.17	<DL	<DL	<DL-0.99	<DL-0.13	<DL	0.11 ± 0.07	<DL	39.6 ± 4.5	1.72 ± 0.16	0.21 ± 0.21
Site 26	5	<DL	<DL	<DL-1.00	<DL	<DL	<DL	<DL-0.12	<DL	17.4 ± 6.7	<DL-0.54	<DL-0.54
Site 27	5	<DL	<DL	<DL	<DL-0.79	<DL	<DL	<DL-0.12	<DL-0.22	23.4 ± 4.0	1.08 ± 0.12	0.35 ± 0.28
Site 16	5	<DL	<DL	<DL-0.15	0.27 ± 0.22	<DL-0.14	<DL	<DL-0.16	<DL-0.21	26.3 ± 12.3	1.07 ± 0.33	0.26 ± 0.10
Site 14	5	<DL	<DL	<DL-0.27	0.90 ± 0.59[a]	<DL-0.32	<DL	<DL-0.21	0.32 ± 0.19	19.6 ± 2.0	0.85 ± 0.38	0.27 ± 0.10
Site 25	5	<DL-0.28	<DL	<DL	1.52 ± 0.70	0.15 ± 0.02	<DL	0.13 ± 0.07	<DL-0.24	70.5 ± 54.1	0.53 ± 0.22	<DL-0.34
Site 32	4	<DL	<DL	<DL-0.23	<DL-2.51	<DL	<DL	<DL	<DL	4.67 ± 2.30	<DL	<DL
Site 33	5	<DL	<DL	<DL	<DL-0.13	<DL	<DL	<DL	<DL	0.13 ± 0.03	<DL	<DL
Site 34 – ref	5	<DL-0.23	<DL-0.13	0.17 ± 0.09	1.21 ± 0.74	1.70 ± 1.82	<DL	0.18 ± 0.17	0.25 ± 0.15	93.2 ± 54.6	0.49 ± 0.44	<DL-0.28
Site 35 – ref	5	<DL	<DL	<DL	<DL-1.26	<DL-0.23	<DL	0.17 ± 0.09	<DL	3.58 ± 0.53	0.29 ± 0.14	<DL
Site 36 – ref	5	<DL	<DL	<DL-0.17	<DL	0.41 ± 0.23	<DL	0.27 ± 0.22	<DL-0.27	8.03 ± 2.80	0.25 ± 0.19	0.18 ± 0.15
Site 38 – ref	5	<DL	<DL-0.12	<DL-0.27	0.39 ± 0.43	0.24 ± 0.20	<DL-0.42	<DL-0.93	<DL-0.13	94.4 ± 35.4	0.47 ± 0.38	0.32 ± 0.16

Average ± Standard Deviation is reported for sites with n=5 or 4. When some samples are < DLs, data are reported as a range. [a]One sample excluded due to atypically high concentration of methoxychlor (137 μg/kg-dw)

Table 13: Chlorinated pesticides (μg/kg dry weight) in Long Creek and Riverside core sediment core samples collected in 2016 from the headpond (see Figure 2) (see Table 16 for guideline exceedances).

Site #	Depth (cm)	Hexachlorobenzene	Aldrin	Dieldrin	Methoxychlor	Σ HCHs	Σ Heptachlor	Σ Chlordane	Σ Nonachlor	Σ DDTs	Σ Endosulfan	Σ Endrin
Long Creek	0.0-2.0	<DL	<DL	0.16	0.20	<DL	<DL	0.71	<DL	33.0	0.15	0.47
Long Creek	2.0-3.0	<DL	<DL	0.18	0.21	<DL	<DL	1.02	0.19	34.2	<DL	0.43
Long Creek	3.0-4.0	<DL	<DL	0.17	<DL	<DL	<DL	0.98	0.13	33.4	<DL	0.26
Long Creek	4.0-5.0	<DL	<DL	0.27	0.49	<DL	<DL	0.96	<DL	34.3	<DL	0.33
Long Creek	5.0-6.0	<DL	<DL	0.22	<DL	<DL	<DL	1.02	<DL	36.2	<DL	0.29
Long Creek	6.0-7.0	<DL	<DL	0.23	0.54	<DL	<DL	0.92	0.14	33.8	<DL	0.62
Long Creek	7.0-8.0	<DL	<DL	0.31	0.43	<DL	<DL	1.09	0.15	42.0	<DL	0.79
Riverside	0.0-2.0	<DL	<DL	0.49	0.54	<DL	<DL	0.53	<DL	21.8	<DL	0.60
Riverside	2.0-4.0	<DL	<DL	0.20	<DL	<DL	<DL	0.45	<DL	29.5	<DL	0.25
Riverside	4.0-5.5	<DL	<DL	<DL	<DL	<DL	<DL	0.49	<DL	23.6	<DL	0.27
Riverside	5.5-7.0	<DL	<DL	<DL	<DL	<DL	<DL	0.55	<DL	19.5	<DL	<DL
Riverside	7.0-8.5	<DL	<DL	<DL	<DL	<DL	<DL	0.64	<DL	19.5	<DL	0.20
Riverside	24.0-25.5	<DL	<DL	<DL	<DL	0.13	<DL	1.03	0.15	34.7	<DL	0.31
Riverside	25.5-26.5	<DL	<DL	0.25	<DL	<DL	<DL	1.24	0.38	43.4	<DL	0.27
Riverside	26.5-27.5	<DL	<DL	<DL	<DL	<DL	<DL	1.21	0.19	35.1	<DL	0.51
Riverside	27.5-28.5	<DL	<DL	<DL	<DL	<DL	<DL	1.35	<DL	42.0	<DL	<DL
Riverside	28.5-30.0	<DL	<DL	0.17	<DL	<DL	<DL	1.20	0.19	36.8	<DL	0.47

Average ± Standard Deviation is reported for sites with n=5 or 4. When some samples are < DLs, data are reported as a range.

Table 14: Chlorinated pesticides (μg/kg dry weight) in Snowshoe Island, Bear Island, NB-AVN and AVN-UP sediment core samples collected in 2016 from the headpond (see Figure 2) (see Table 17 for guideline exceedances).

Site #	Depth (cm)	Hexachlorobenzene	Aldrin	Dieldrin	Methoxychlor	Σ HCHs	Σ Heptachlor	Σ Chlordane	Σ Nonachlor	Σ DDTs	Σ Endosulfan	Σ Endrin
Snowshoe Island	0.0-2.0	<DL	<DL	<DL	0.17	<DL	<DL	<DL	<DL	8.49	1.33	<DL
Snowshoe Island	6.0-7.0	0.19	0.12	0.30	<DL	<DL	0.20	0.33	0.28	43.6	1.03	0.36
Snowshoe Island	11.0-12.0	<DL	<DL	<DL	<DL	<DL	0.15	0.46	<DL	12.4	<DL	<DL
Bear Island	0.0-1.0	<DL	<DL	0.37	<DL	<DL	0.20	0.76	0.41	53.1	0.70	0.31
Bear Island	9.0-10.0	0.15	<DL	0.68	<DL	<DL	0.27	0.93	0.28	46.1	0.70	0.20
Bear Island	18.0-19.0	0.14	<DL	0.50	<DL	0.15	0.23	0.49	0.44	58.3	0.74	0.33
NB-AVN	0.0-1.0	<DL	<DL	0.33	<DL	<DL	0.33	0.53	1.70	33.3	1.32	0.64
NB-AVN	10.0-11.0	0.12	<DL	0.27	<DL	<DL	0.20	0.47	0.28	64.2	1.29	0.29
NB-AVN	22.0-23.0	0.42	<DL	0.17	<DL	0.14	0.16	0.64	0.24	24.6	0.48	0.13
AVN-UP	0.0-1.0	<DL	<DL	0.36	<DL	<DL	0.18	0.31	0.33	35.6	1.38	0.25
AVN-UP	8.0-9.0	<DL	<DL	<DL	<DL	<DL	<DL	0.45	0.17	14.6	0.39	<DL
AVN-UP	17.0-18.0	<DL	<DL	0.04	<DL	<DL	<DL	<DL	0.19	10.7	0.35	<DL

Average ± Standard Deviation is reported for sites with n=5 or 4. When some samples are < DLs, data are reported as a range.

Table 15: Chlorinated pesticides and total polychlorinated biphenyls (μg/kg-dry weight) with CCME Guidelines in surface sediment samples collected in 2015 from the headpond and downstream sites and reference lakes (see Figure 1). Sites are listed from upstream to downstream in the headpond. Bolded numbers are above the CCME ISQG. Bolded and italicized numbers are above the CCME PEL values.

Site #	n	γ-HCH (Lindane)	Heptachlor epoxide (Isomer B)	Dieldrin	Endrin	ΣChlordane (α + γ)	ΣDDE	ΣDDD	ΣDDT	Total PCBs
ISQG	-	0.94	0.6	2.85	2.67	4.5	1.42	3.54	1.19	34.1
PEL	-	1.38	2.74	6.67	62.4	8.87	6.75	8.51	4.77	277
Site 31	5	<DL-0.13	<DL	<DL	<DL-0.21	<DL-0.16	**2.96 ± 1.79**	2.50 ± 1.26	**2.04 ± 1.50**	<DL-0.16
Site 2	5	<DL	<DL	<DL	<DL-0.16	<DL	**1.73 ± 0.8**	1.10 ± 0.28	0.80 ± 0.55	<DL-0.50
Site 29	5	<DL	<DL-0.24	<DL-0.15	<DL-0.32	0.34 ± 0.19	***15.1 ± 6.4***	**8.24 ± 1.70**	***11.2 ± 4.6***	1.97 ± 1.96
Site 28	5	<DL	<DL	<DL	<DL	0.11 ± 0.07	***15.9 ± 3.3***	***10.7 ± 1.0***	***13.0 ± 3.0***	0.26 ± 0.17
Site 26	5	<DL	<DL	<DL-1.00	<DL-0.21	<DL-0.12	**6.48 ± 2.47**	**5.43 ± 1.13**	***5.48 ± 3.66***	0.30 ± 0.29
Site 27	5	<DL	<DL	<DL	<DL-0.16	<DL-0.12	***9.96 ± 2.62***	**6.76 ± 0.57**	***6.64 ± 1.14***	0.70 ± 0.58
Site 16	5	<DL	<DL	<DL-0.15	<DL-0.21	<DL-0.16	***9.15 ± 1.2***	**5.69 ± 3.24**	***11.5 ± 8.8***	1.05 ± 0.59
Site 14	5	<DL	<DL	<DL-0.27	<DL-0.25	<DL-0.21	***8.56 ± 1.05***	**7.35 ± 0.44**	**3.65 ± 1.48**	3.44 ± 0.83
Site 25	5	<DL	<DL	<DL	<DL	0.13 ± 0.07	***17.6 ± 4.6***	***36.8 ± 20.3***	**1.51 ± 0.54**	1.43 ± 1.18
Site 32	4	<DL	<DL	<DL-0.23	<DL-0.16	<DL	**1.45 ± 0.83**	1.32 ± 0.61	**1.90 ± 1.00**	1.42 ± 0.88
Site 33	5	<DL	<DL	<DL	<DL-0.21	<DL	<DL	<DL-0.13	<DL-0.15	<DL-0.12
Site 34 – ref	5	<DL-**2.05**	<DL	0.17 ± 0.09	<DL-0.14	0.18 ± 0.17	***35.9 ± 26.0***	***55.5 ± 30.4***	**1.78 ± 1.04**	5.18 ± 3.53
Site 35 – ref	5	<DL	<DL	<DL	<DL-0.21	0.17 ± 0.09	**1.44 ± 0.37**	1.92 ± 0.30	0.22 ± 0.14	1.00 ± 0.71
Site 36 – ref	5	<DL	<DL	<DL-0.17	<DL-0.16	0.27 ± 0.22	**2.91 ± 1.18**	**4.95 ± 1.60**	<DL-0.42	2.45 ± 1.01
Site 38 – ref	5	<DL-0.14	<DL-0.42	<DL-0.27	<DL-0.21	<DL-0.93	***39.6 ± 10.3***	***53.1 ± 25.1***	**1.63 ± 0.59**	3.01 ± 1.45

CCME ISQG is Interim Sediment Quality Guidelines (CCME, 1998-2001). PEL is Probable Effects Level (CCME). Samples and guidelines are in ug/kg-dry weight. Average ± Standard Deviation are reported for sites with n=5 and nd means not detected. When some samples are < DLs, data are reported as a range

Table 16: Chlorinated pesticides and total polychlorinated biphenyls (µg/kg-dry weight) with CCME Guidelines in Long Creek and Riverside sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG. Bolded and italicized numbers are above the CCME PEL values.

Site #	Depth (cm)	γ-HCH (Lindane)	Heptachlor epoxide (Isomer B)	Dieldrin	Endrin	Σ Chlordane (α + γ)	ΣDDE	ΣDDD	ΣDDT	Total PCBs
ISQG		0.94	0.6	2.85	2.67	4.5	1.42	3.54	1.19	34.1
PEL		1.38	2.74	6.67	62.4	8.87	6.75	8.51	4.77	277
Long Creek	0.02.0	<DL	<DL	0.16	0.30	0.71	***12.4***	***10.2***	***10.4***	1.06
Long Creek	2.0-3.0	<DL	<DL	0.18	<DL	1.02	***11.4***	***10.5***	***12.3***	2.04
Long Creek	3.0-4.0	<DL	<DL	0.17	<DL	0.98	***11.6***	***10.1***	***11.7***	1.81
Long Creek	4.0-5.0	<DL	<DL	0.27	<DL	0.96	***12.1***	***10.5***	***11.7***	3.26
Long Creek	5.0-6.0	<DL	<DL	0.22	<DL	1.02	***13.1***	***11.9***	***11.3***	2.87
Long Creek	6.0-7.0	<DL	<DL	0.23	0.17	0.92	***12.0***	***10.8***	***11.0***	5.59
Long Creek	7.0-8.0	<DL	<DL	0.31	0.25	1.09	***14.0***	***13.7***	***14.3***	5.64
Riverside	0.0-2.0	<DL	<DL	0.49	0.32	0.53	***8.55***	**4.81**	***8.48***	<DL
Riverside	2.0-4.0	<DL	<DL	0.20	<DL	0.45	***12.4***	**6.93**	***10.2***	0.30
Riverside	4.0-5.5	<DL	<DL	<DL	<DL	0.49	***11.5***	***9.93***	**2.23**	0.26
Riverside	5.5-7.0	<DL	<DL	<DL	<DL	0.55	***9.71***	**7.43**	**2.32**	0.24
Riverside	7.0-8.5	<DL	<DL	<DL	<DL	0.64	***9.26***	**7.76**	**2.47**	0.18
Riverside	24.0-25.5	0.13	<DL	<DL	<DL	1.03	***16.2***	***14.2***	**4.43**	6.70
Riverside	25.5-26.5	<DL	<DL	0.25	<DL	1.24	***22.1***	***15.5***	***5.76***	5.49
Riverside	26.5-27.5	<DL	<DL	<DL	<DL	1.21	***16.2***	***13.7***	***5.23***	5.39
Riverside	27.5-28.5	<DL	<DL	<DL	<DL	1.35	***17.5***	***18.1***	***6.42***	8.51
Riverside	28.5-30.0	<DL	<DL	0.17	<DL	1.20	***16.0***	***16.8***	**4.01**	14.5

CCME ISQG is Interim Sediment Quality Guidelines (CCME, 1998-2001). PEL is Probable Effects Level (CCME). Samples and guidelines are in µg/kg-dry weight.
Average ± Standard Deviation are reported for sites with n=5 and nd means not detected.

Table 17: Chlorinated pesticides and total polychlorinated biphenyls (µg/kg-dry weight) with CCME Guidelines in Snowshoe Island, Bear Island, NB-AVN and AVN-UP sediment core samples collected in 2016 from the headpond (see Figure 2). Bolded numbers are above the CCME ISQG. Bolded and italicized numbers are above the CCME PEL values.

Site #	Depth (cm)	γ-HCH (Lindane)	Heptachlor epoxide (Isomer B)	Dieldrin	Endrin	Σ Chlordane (α + γ)	ΣDDE	ΣDDD	ΣDDT	Total PCBs
ISQG		0.94	0.6	2.85	2.67	4.5	1.42	3.54	1.19	34.1
PEL		1.38	2.74	6.67	62.4	8.87	6.75	8.51	4.77	277
Snowshoe Island	0.0-2.0	<DL	<DL	<DL	<DL	<DL	**2.86**	2.12	**3.50**	1.22
Snowshoe Island	6.0-7.0	<DL	<DL	0.30	<DL	0.33	***13.5***	***14.2***	***14.8***	9.94
Snowshoe Island	11.0-12.0	<DL	<DL	<DL	<DL	0.46	**3.00**	2.56	**1.22**	7.99
Bear Island	0.0-1.0	<DL	0.20	0.37	<DL	0.76	***15.9***	***10.3***	***22.7***	2.93
Bear Island	9.0-10.0	<DL	<DL	0.68	<DL	0.93	***16.2***	***11.5***	***12.0***	8.61
Bear Island	18.0-19.0	0.15	<DL	0.50	<DL	0.49	***17.8***	***20.8***	***16.4***	20.8
NB-AVN	0.0-1.0	0.14	<DL	0.33	0.27	0.53	***10.9***	**4.79**	***11.5***	7.63
NB-AVN	10.0-11.0	<DL	<DL	0.27	<DL	0.47	***23.3***	***14.5***	***23.8***	7.47
NB-AVN	22.0-23.0	0.14	<DL	0.17	<DL	0.64	***8.60***	**4.65**	***6.79***	7.69
AVN-UP	0.0-1.0	<DL	<DL	0.36	0.25	0.31	***14.3***	**5.28**	***14.6***	8.50
AVN-UP	8.0-9.0	<DL	<DL	<DL	<DL	0.45	**4.50**	2.68	***6.10***	4.54
AVN-UP	17.0-18.0	<DL	<DL	<DL	<DL	<DL	**4.70**	2.60	**3.43**	4.20

CCME ISQG is Interim Sediment Quality Guidelines (CCME, 1998-2001). PEL is Probable Effects Level (CCME). Samples and guidelines are in ug/kg-dry weight. Average ± Standard Deviation are reported for sites with n=5 and nd means not detected.

Polychlorinated Biphenyls

Headpond and Downstream Surface Sediments

Concentrations of individual PCBs in the headpond and downstream sediments were low, and most were below detection limits. Of the 64 PCBs examined, site 29 (n=5) had 0 to 22 individual PCBs detected, some of which were close to or at the detection limit. Forty nine of 64 PCBs were detected across all sites (n=5 for all sites; except site 32 which was n=4). The most frequently occurring PCBs (at more than 5 sites) were: 28, 31, 70, 118, 153 and 180. Thirteen PCBs were found in 3-4 sites (66/95, 99, 97, 151, 123/149, 163/138, 174, 170, 195, and 206). Thirty other PCBs were detected at 1-2 sites (17/15, 16/32, 53, 52, 49, 47, 56/60/92, 101, 85, 77/110, 131, 132/105, 126/78, 187, 128/167, 202/171/156, 157, 190, 201 and 194). Total PCBs were detectable at all sites but not at all replicates (Table 15). Sites 02, 31 and 33 ranged from <DL to 0.50 µg/kg-dw. The other sites had mean total PCB concentrations that ranged from 0.30 to 3.44 µg/kg-dw.

Total PCBs in all surface sediments were at least 9 fold lower than the ISQG from CCME.

Total PCBs were also ranked and compared across sites. The lowest ranked sites were 33, 31 and 32. The highest ranked sites were found to be 16, 25 and 14.

When compared to samples collected from the headpond in 2014, the 2015 samples tended to have higher total PCB concentrations.

Reference Lake Surface Sediments

As seen in the headpond the concentrations of individual PCBs were also low in the reference lakes. Out of 64 possible congeners, 50 were detected across all reference lake samples. Site 34 contained the most individual PCBs with up to 25 congeners present in a single sample. Eighteen congeners were found to be the most frequent (found in 3-4 sites: 31, 28, 52, 47, 74, 70, 101, 85, 151, 118, 153, 132/105, 163/138, 174, 180, 194). Congeners (total of 30) occurring in 1-2 of the 4 reference lakes were: 8/5, 18/ 17/15, 53, 33, 22, 49, 44, 66/995, 91, 99, 97, 81/87, 77/110, 123/149, 126/178, 123/149, 126/178, 187, 128/167, 170, 201, 195 and 206. All reference lakes contained total PCB concentrations that ranged from 1.00 to 5.18 µg/kg-dw at sites 35 and 34, respectively (Table 15). All total PCB concentrations were ~6 fold less that the ISQG.

Total PCBs were ranked and compared across the headpond and the reference sites. The highest ranked sites were in the headpond - 16, 25 and 14. The lowest ranked sites were 33 and reference sites 35, 36 and 38. This implies that 3 of the reference sites (35, 36 and 38) had lower total PCBs than the headpond. At reference site 34, total PCBs were lower or equal to half of the headpond sites analyzed.

Headpond Sediment Cores

PCBs were found in all sediment cores, except for the top slice (0.0 to 2.0 cm) at Riverside which was below DLs (Tables 16 and 17). Across all core samples, 54 of 64 PCBs were measured at or above the detection limits. Twenty of the PCBs were found in 1 to 3 sites at varying depths (16/32, 33, 22, 52, 71/64/41, 74, 101, 81/87, 85, 77/110, 187, 157, 199, 201 and 195). The following 34 PCBs were found in 4 to 6 of the sites (the bolded PCBs were found in all sediment cores sampled in 2016) at various depths: 31, **28**, **49**, 47, **44, 70**, **66/95**, 91**, 56/60/92**, 99, **97**,

151, 135/144, **123/149**, 118, **153**, **132/105**, **163/138**, 126/178, **128/167**, **174**, **180**, **170**, **194** and **206**. Concentrations of total PCBs ranged from < DL to 20.8 µg/kg-dw, and were higher in the deeper slices of the Long Creek, Riverside and Bear Island cores. In contrast, this group of contaminants was present at similar concentrations in all slices of the NB-AVN core, higher concentrations in the middle slice of the Snowshoe Island core, and higher concentrations in the surface slice of the AVN-UP core.

All core samples at all depths were consistently below the CCME Guidelines (see Tables 16 and 17).

Chlorinated Pesticides

Headpond and Downstream Surface Sediments

Of the individual chlorinated pesticides or breakdown products analyzed in this study, aldrin was below detection limits at all 11 sites (Table 12). Hexachlorobenzene was only detected in 2 sites (25 and 28) with concentrations ranging from <DL to 0.28 µg/kg-dw; the highest concentration was found in site 25. Dieldrin was present in 5 of the 11 sites with the highest concentration in site 26 (1.00 µg/kg-dw). <DL to 2.09 µg/kg-dw concentrations were found for methoxychlor, where the greatest concentration was found at site 2. ΣHCHs, Σchlordane and Σendrin were low at all sites with the highest being at site 29 (0.21 µg/kg-dw, 0.34 µg/kg-dw and 0.48 µg/kg-dw respectively). ΣHeptachlor was below detection limits for all sites except site 29 which ranged from <DL to 0.24 µg/kg-dw. ΣNonachlor was highest at site 14 (0.32 µg/kg-dw). ΣEndosulfan ranged from <DL to 1.74 µg/kg-dw across all sites, with site 29 being the highest. The ΣDDTs (all 6 congeners) was found to have the highest concentrations of all the chlorinated pesticides in this report (0.13-70.5 µg/kg-dw; sites 33 and 25 respectively).

Table 15 shows the pesticides that were found above the ISQG or PEL levels. Guidelines for the chlorinated pesticides for ΣDDE, ΣDDD and ΣDDT were exceeded for several sites within the headpond. More specifically, ΣDDE was greater than the ISQG for all sites except 33. The concentrations in 6 sites were higher than the PEL guidelines. For ΣDDD the ISQG were exceeded for 7 sites with 2 of these sites (25 and 28) above the PELs. Sites 02, 31, 32 and 33 did not exceed any guidelines for ΣDDE. ΣDDT concentrations surpassed the ISQG at 9 sites and the PELs at 5. Sites 02 and 33 were below all guidelines.

The ranking exercise for the headpond chlorinated sediments resulted in sites 33, 32, 31 and 02 as the lowest and sites 16, 29 and 14 as the highest.

When compared to 2014 data, aldrin and dieldrin were detected at fewer sites and Σchlordane, Σendrin and Σendosulfan were present at some lower concentrations in sediments from 2015. Other chlorinated pesticides were similar among years both with respect to detection frequencies and concentrations.

Reference Lake Surface Sediments

Most chlorinated pesticides were found at similar frequencies and concentrations as in the surface sediments from the headpond. Hexachlorobenzene was only detected at site 34, aldrin at sites 34 and 38, and Σheptachlor at site 38 (Table 12). The pesticides that were present in 3 of the 4 reference lakes and their maximum concentrations were: dieldrin (0.27 µg/kg-dw; site 38), methoxychlor (1.21 µg/kg-dw; site 34), ΣHCHs (1.70 µg/kg-dw; site 34), Σnonachlor (0.27 µg/kg-dw; site 36) and Σendrin (0.32 μg/kg-dw; site 38). Those found at all reference sites were: Σchlordane, ΣDDTs, Σendosulfan, ΣDDE, ΣDDD and ΣDDT, and the pesticide at the highest concentrations was DDT.

Out of all the chlorinated pesticides ΣDDE, ΣDDD and ΣDDT were the only ones exceeding the guidelines for the reference lakes. ΣDDE was greater than ISQG at all lakes and greater than PELs at sites 34 and 38. ΣDDD exceeded ISQG for all sites except 35 and exceeded PELs at sites 34 and 38. ΣDDT was only above guidelines at 2 lakes; sites 34 and 38.

When the reference sites were added to the ranking exercise the lower-ranked sites for all chlorinated pesticides were 33, 34, 32, 36, 02 and 31 (the last 5 sites tied). The greater-ranked sites were 38, 16, 19, 34 and 11 with the first three tied. The ranking indicated that most headpond sites (7 sites) had higher pesticide concentrations than sites 35 and 36 (both reference sites) and that reference sites 38 and 34 had similar or higher concentrations than those found in the headpond.

Headpond Sediment Cores

Long Creek and Riverside Sediment Cores

For both Long Creek and Riverside (Tables 13 and 16) cores, several chlorinated pesticides were less than the detection limits; these were hexachlorobenzene, aldrin, Σheptachlor and heptachlor epoxide (Isomer B). Pesticides that had 1-2 sites with values greater than the DLs were; ΣHCHs (Riverside; 24.0-25.5 cm), Σendosulfan (Long Creek; 0.0-2.0 cm) and γ-HCH (Riverside; 24.0-25.5 cm). Dieldrin, methoxychlor and Σnonachlor were often <DLs; the highest concentrations found throughout Long Creek were 0.31, 0.54, 0.19 μg/kg-dw, respectively. Within the Riverside core the greatest concentrations of these three pesticides were 0.49, 0.54, 0.38 μg/kg-dw, respectively. For both cores, endrin was present in most slices, and Σchlordane and ΣDDTs were found at all depths. ΣDDE, ΣDDD and ΣDDT were found at the highest concentrations of all chlorinated pesticides. Dieldrin and methoxychlor were found at the highest concentrations in the deeper slices of Long Creek and the shallowest slices at Riverside. ΣChlordane was higher in the deeper slices of the Riverside core, and ΣDDTs were higher at greater depths in both cores. ΣEndrin was highest in the deep slice from the Long Creek core.

ΣDDE, ΣDDD and ΣDDT were the only chlorinated pesticides that exceeded the guidelines (Table 16). All depths of both the Long Creek and Riverside cores were greater than the ISQG for ΣDDE, ΣDDD and ΣDDT. All depths for ΣDDE, ΣDDD and ΣDDT also exceeded PELs for Long Creek. For Riverside, these PELs were exceeded for several depths of the core; ΣDDE (0.0-8.5 cm and 24.0-30.0 cm), ΣDDD (4.0-5.5cm and 24.0-30.0 cm) and ΣDDT (0.0-4.0, 25.5-28.5 cm).

Snowshoe Island, Bear Island, NB-AVN and AVN-UP Sediment Cores

Chlorinated pesticides for Snowshoe Island, Bear Island, NB-AVN and AVN-UP are shown in Tables 14 and 17 (with guidelines).

Samples from the Snowshoe Island core were all below detection ΣHCHs and six pesticides were detected only at 1 depth; these were hexachlorobenzene, aldrin, dieldrin, Σendrin and Σnonachlor all at 6.0-7.0 cm. Methoxychlor was found at the surface of this core whereas Σheptachlor and Σchlordane were both found in the two deeper slices. ΣEndosulfan was detected at 0.0-2.0 and 6.0-7.0 cm depths. The limited samples made it difficult to see overall trends in pesticide concentrations with core depth.

Sediment slices from the Bear Island, NB-AVN and AVN-UP cores had concentrations less than DLs for aldrin and methoxychlor, and ΣDDTs, ΣDDT, ΣDDD and ΣDDE were found at the highest concentrations. There was some variability in other pesticide concentrations in these cores but no consistent trends across the three sites. For example, ΣDDTs were at the highest concentration in the deepest slice for Bear Island, the middle slice for NB-AVN, and the surface slice for AVN-UP.

More specifically for the Bear Island core, ΣHCHs were highest in the deepest slice (0.15 µg/kg-dw), and hexachlorobenzene was found in the two deeper slices with 0.15 µg/kg-dw as the maximum. The remaining chlorinated pesticides were found at all depths tested. Dieldrin, Σheptachlor, Σchlordane, Σnonachlor, ΣDDTs (6 congeners), Σendosulfan, Σendrin, ΣDDE, ΣDDD, and ΣDDT were found in ranges of 0.37-0.68, 0.20-0.27, 0.49-0.93, 0.28-0.44, 46.1-58.3, 0.70-0.74, 0.20-0.33, 15.9-17.8, 10.3-20.8, and 12.0-22.7 µg/kg-dw, respectively.

NB-AVN core samples had detectable concentrations for the following pesticides (maximum concentrations; depths found) - hexachlorobenzene (0.42 µg/kg-dw; 22.0-23.0 cm), HCH (0.14 µg/kg-dw; 22.0-23.0 cm) and Σendrin (0.64 µg/kg-dw; 0.0-1.0 cm). Similar to the other cores, Σheptachlor, Σchlordane, Σnonachlor, ΣDDTs (6 congeners), Σendosulfan, Σendrin, ΣDDE, ΣDDD, and ΣDDT were found at all depths with concentrations of 0.17-0.33, 0.16-0.33, 0.47-0.64, 0.24-1.70, 24.6-64.2, 0.48-1.3, 0.13-0.64, 8.6-23.3, 4.65-14.5 and 6.79-23.8 µg/kg-dw, respectively.

Lastly, the core samples from AVN-UP were lower than the detection limits for hexachlorobenzene and ΣHCHs, but had detectable amounts (and highest) for dieldrin (0.36 µg/kg-dw), Σheptachlor (0.18 µg/kg-dw), Σchlordane (0.45 µg/kg-dw) and Σendrin (0.25 µg/kg-dw). Other pesticides that were detected at all depths (0.0-1.0, 8.0-9.0 and 17.0-18.0 cm) were: Σnonachlor (0.17-0.33 µg/kg-dw), ΣDDTs (10.7-35.6 µg/kg-dw), Σendosulfan (0.35-1.38 µg/kg-dw), ΣDDE (4.5-14.3 µg/kg-dw), ΣDDD (2.60- 5.28 µg/kg-dw), and ΣDDT (3.43-14.6 µg/kg-dw).

With respect to the sediment quality guidelines for all of these cores (Table 17), only ΣDDE, ΣDDD and ΣDDT in exceedance for at least one depth tested. All 4 sites exceeded the ISQG for ΣDDE in all samples; PELs were exceeded for Snowshoe Island (6.0-7.0 cm), Bear Island (all depths), NB-AVN (all depths) and AVN-UP (0.0-1.0 cm). For ΣDDD, Snowshoe Island was greater than the PEL at 6.0-7.0 cm and Bear Island at all depths, NB-AVN was above the ISQG at all depths and the PEL at 10.0-11.0 cm, and AVN-UP was above the ISQG at 0.0-1.0 cm. Finally, ΣDDT was above ISQG for all sites. Some samples were above PELs for ΣDDT at Snowshoe Island (6.0-7.0 cm), Bear Island (all sections), NB-AVN (all sections) and AVN-UP (0.0-1.0 and 8.0-9.0 cm).

Table 18: Organic carbon (%), Kjeldahl nitrogen (mg/kg-dw) and total inorganic carbon (%) in surface sediment samples collected in 2015 from the headpond and reference lakes (see Figure 1). Sites are listed from upstream to downstream in the headpond.

Site #	n	Organic Carbon (%)	Kjeldahl Nitrogen (mg/kg-dw)	Total Inorganic Carbon (%)
Site 31	1	1.0	1130	-
Site 2	1	0.5	420	-
Site 29	1	3.2	2820	-
Site 28	1	2.3	2280	0.089
Site 26	1	3.6	3570	0.072
Site 27	1	3.0	3000	0.018
Site 16	1	2.4	2450	-
Site 14	1	2.2	2640	-
Site 25	1	5.7	3570	-
Site 32	1	4.7	2570	0.012
Site 33	1	0.1	210	-
Site 34 – ref	1	6.6	6750	-
Site 35 – ref	1	9.3	7430	-
Site 36 – ref	1	11.0	11300	-
Site 38 – ref	1	13.1	10700	-

Organic Carbon, Nitrogen and Phosphorous

Headpond and Downstream Surface Sediments

Percent organic carbon in the headpond ranged from 0.5 to 5.7% (Table 18). Sites 32 and 33 downstream of the dam had similar values of organic carbon. Only 4 sites were tested for inorganic carbon with results ranging from 0.012 to 0.089%. Nitrogen (TKN) had a wide range of values within the headpond (420-3570 mg/kg-dw) and downstream of the dam (210, 2570 mg/kg-dw).

Reference Lake Surface Sediments

The four reference lakes were found to have higher organic carbon in sediments than was observed in the headpond, with a range of 6.6-13.1% (Table 18). The same was found for TKN at 6750-10700 mg/kg-dw.

Table 19: Organic carbon (%), Kjeldahl nitrogen (mg/kg-dw) and total inorganic carbon (%) in sediment core samples collected in 2016 from the headpond (see Figure 2).

Site #	Depth (cm)	n	Organic Carbon (%)	Kjeldahl Nitrogen (mg/kg-dw)	Total Inorganic Carbon (%)
Long Creek	0.02.0	1	2.51	2400	< 0.05
Long Creek	2.0-3.0	1	2.30	2200	< 0.05
Long Creek	3.0-4.0	1	2.46	2200	< 0.05
Long Creek	4.0-5.0	1	2.38	2100	< 0.05
Long Creek	5.0-6.0	1	2.51	2400	< 0.05
Long Creek	6.0-7.0	1	2.53	2300	< 0.05
Long Creek	7.0-8.0	1	2.58	2300	< 0.05
Riverside	0.0-2.0	1	3.01	3100	< 0.05
Riverside	2.0-4.0	1	3.01	3300	< 0.05
Riverside	4.0-5.5	1	3.10	3300	< 0.05
Riverside	5.5-7.0	1	2.64	2500	< 0.05
Riverside	7.0-8.5	1	2.03	2300	< 0.05
Riverside	24.0-25.5	1	2.56	2600	< 0.05
Riverside	25.5-26.5	1	2.45	2200	< 0.05
Riverside	26.5-27.5	1	2.52	2400	< 0.05
Riverside	27.5-28.5	1	2.73	2500	< 0.05
Riverside	28.5-30.0	1	2.66	1800	< 0.05
Snowshoe Island	0.0-1.0	1	2.70	2800	< 0.05
Snowshoe Island	1.0-2.0	1	2.46	2500	< 0.05
Snowshoe Island	6.0-7.0	1	2.22	2300	< 0.05
Snowshoe Island	11.0-12.0	1	1.65	1600	< 0.05
Bear Island	0.0-1.0	1	2.94	2700	< 0.05
Bear Island	9.0-10.0	1	2.31	2300	< 0.05
Bear Island	18.0-19.0	1	2.60	2200	< 0.05
NB-AVN	0.0-1.0	1	3.53	3200	< 0.05
NB-AVN	10.0-11.0	1	3.35	2700	< 0.05
NB-AVN	22.0-23.0	1	2.31	2000	< 0.05
AVN-UP	0.0-1.0	1	4.13	3500	< 0.05
AVN-UP	8.0-9.0	1	2.74	1800	< 0.05
AVN-UP	17.0-18.0	1	1.95	1900	< 0.05

Headpond Sediment Cores

Percent organic carbon in the core samples had similar ranges; values for Long Creek, Riverside, Snowshoe Island, Bear Island, NB-AVN and AVN UP were 2.31-2.58, 2.03-3.10, 1.65-2.70, 2.31-2.94, 2.31-3.53 and 1.95-4.13, respectively (Table 19). Organic carbon content was higher in the surface slices of all cores but those of Long Creek. TKN values in these same cores ranged from 2100-2400, 1800-3300, 1600-2800, 2200-2700, 2000-3200 and 1800-3500 mg/kg-dw, respectively. TKN tended to be higher in surface sediments than deeper sediments from all cores but those of Long Creek. All inorganic carbon results were less than detection limits at all core sites and depths. These results are similar to those found in the surface sediment samples.

Summary

The following summary focuses only on those contaminants with sediment (ISQG, PEL) or soil (SQG) quality guidelines and summarizes results for the average concentrations (when replicates were taken) measured across sites for surface sediments (Note: n=9 sites in headpond; 2 downstream sites excluded here) and individual slices analyzed in the cores (total of 6 cores) collected in 2015 and 2016. Results from the 2014 headpond sampling (n=12 sites; Kidd et al. 2016) and reference lakes (n=4; this report) are included below for comparison. A general qualitative statement is made in italics about guideline exceedances for each contaminant for the headpond only, followed by details on the numbers and types of exceedances for each group of samples collected in 2014-2016. Guideline values are found in the tables in this report.

<u>Metals and Elements</u>

Arsenic

This metal was <u>often</u> above a guideline (mainly ISQG) in surface sediments and cores from the headpond.

- Headpond surface sediments 2015 – 8 of 9 sites above a guideline
  - > ISQG at 6 sites
  - > PEL at 1 site
  - > SQG at 3 sites
- Headpond surface sediments 2014 – 11 of 12 sites above a guideline
  - > ISQG at 9 sites
  - > PEL at 2 sites
  - > SQG at 7 sites
- Headpond sediment cores 2016 – All core slices above a guideline
  - > ISQG for all slices of Long Creek core
  - > ISQG for all Riverside core slices at 1.0-2.0 cm, 2.5-3.0 cm, 3.5-8.5 cm and 24.0-30.0 cm
  - > ISQG for all Snowshoe Island slices except the deepest one (11.0-12.0 cm)
  - > ISQG for all Bear Island core slices
  - > ISQG for all NB-AVN core slices
  - > ISQG for AVN-UP slice at 0.0-1.0 cm
  - > PEL for Riverside core slices from 0.0-1.0 cm, 2.0-2.5 cm and 3.0-3.5 cm
  - > SQG for Riverside core slices from 0.0-4.0 cm and 4.5-5.0 cm
  - > SQG for Snowshoe Island core slices 0.0-2.0 cm
  - > SQG for Bear Island core at 0.0-1.0 cm
- Reference lake surface sediments 2015 –All lakes above a guideline
  - > ISQG for all lakes
  - > SQG for Miramichi Lake (site 38)

Cadmium

This metal was <u>never</u> above the guidelines in samples from the headpond.

- Headpond surface sediments 2015 – No sites above a guideline

- Headpond surface sediments 2014 – No sites above a guideline
- Headpond sediment cores 2016 - No slices above a guideline
- Reference lake surface sediments 2015 – Three lakes above one guideline
    - > ISQG at all lakes except site 34 (Davidson Lake)

Chromium

This metal was <u>often</u> above the ISQG in surface sediments and cores from the headpond.

- Headpond surface sediments 2015 – 8 of 9 sites above a guideline
    - > ISQG at 8 sites
- Headpond surface sediments 2014 – All sites above a guideline
    - > ISQG at 12 sites
- Headpond sediment cores 2016 – All core slices above a guideline
    - > ISQG for all slices of Long Creek core
    - > ISQG for all slices of Riverside core
    - > ISQG for all slices of Snowshoe Island core
    - > ISQG for all slices of Bear Island core
    - > ISQG for all slices of NB-AVN core
    - > ISQG for AVN-UP slice at 0.0-1.0 cm
    - > SQG for Riverside core slice 7.0-7.5 cm
- Reference lake surface sediments 2015 –One lake above a guideline
    - > ISQG for Davidson Lake (site 34)

Cobalt

This metal was <u>never</u> above the SQG guideline in samples from the headpond.

- Headpond surface sediments 2015 – No sites above SQG
- Headpond surface sediments 2014 – No sites above SQG
- Headpond sediment cores 2016 - No slices above SQG
- Reference lake surface sediments 2015 – No lakes above SQG

Copper

This metal was <u>rarely</u> above a guideline (only ISQG) in samples from the headpond.

- Headpond surface sediments 2015 – No sites above a guideline
- Headpond surface sediments 2014 – No sites above a guideline
- Headpond sediment cores 2016 – Two cores with slices above a guideline
    - > ISQG for Bear Island core at 9.0-10.0 cm
    - > ISQG for Long Creek core at 2.5-3.0 cm
- Reference lake surface sediments 2015 – No lakes above a guideline

Lead

This metal was <u>rarely</u> above a guideline (only ISQG) in samples from the headpond.

- Headpond surface sediments 2015 – No sites above a guideline
- Headpond surface sediments 2014 – No sites above a guideline
- Headpond sediment cores 2016 – One core with slices above a guideline
    - > ISQG for Riverside core at 29.0-29.5 cm and 29.5-30.0 cm
- Reference lake surface sediments 2015 – Two lakes above a guideline
    - > ISQG for Davidson Lake (site 34) and Skiff Lake (site 36)

Nickel

This metal was <u>often</u> above a guideline (mainly PEL) for samples from the headpond.

- Headpond surface sediments 2015 – All sites above a guideline
  - > ISQG at 1 site
  - > PEL at 8 sites
  - > SQG at 4 sites
- Headpond surface sediments 2014 – All sites above a guideline
  - > PEL at 12 sites
  - > SQG at 3 sites
- Headpond sediment cores 2016 – All core slices above a guideline
  - > PEL for all depths of Long Creek core
  - > PEL for all depths of Riverside core
  - > PEL for all depths of Snowshoe Island core
  - > PEL for all depths of Bear Island core
  - > PEL for all depths of NB-AVN core
  - > PEL for all depths of AVN-UP core
  - > SQG for Long Creek core at 2.5-4.0 cm
  - > SQG for Riverside core at 3.0-5.0 cm, 5.5-6.5 cm, 7.0-8.5 cm, 24.0-25.5 cm and 29.0-30.0 cm
  - > SQG for Snowshoe Island core at 0–1.0 cm, 1.0–2.0 cm and 6.0-7.0 cm
- Reference lake surface sediments 2015 – All lakes above a guideline
  - > ISQG for Skiff Lake (site 36), Little Magaguadavic Lake (site 35), and Miramichi Lake (site 38)
  - > PEL for Davidson Lake (site 34)

Thallium

This metal was <u>occasionally</u> above the soil quality guideline in samples from the headpond.

- Headpond surface sediments 2015
  - > SQG at 1 site
- Headpond surface sediments 2014
  - > SQG at 4 sites
- Headpond sediment cores 2016
  - > SQG in all slices from Long Creek core except 7.0-7.5 cm
  - > SQG in all upper slices (except 1.5-2.0 cm) and only two deeper slices (24.0-24.5 cm and 24.5-25.0 cm) from Riverside core
  - > SQG in Snowshoe Island core at 0.0-1.0 cm
- Reference lake surface sediments 2015 – No lakes above SQG

Total Mercury (THg)

This metal was <u>never</u> above guidelines in samples from the headpond.

- Headpond surface sediments 2015 – No sites above guidelines
- Headpond surface sediments 2014 – No sites above guidelines
- Headpond sediment cores 2016 - No slices above guidelines
- Reference lake surface sediments 2015 – One lake above the ISQG (Little Magaguadavic Lake, site 35)

Vanadium

This metal was <u>never</u> above the soil quality guideline in samples from the headpond.

- Headpond surface sediments 2015 – No sites above soil quality guideline
- Headpond surface sediments 2014 – No sites above soil quality guideline
- Headpond sediment cores 2016 - No slices above soil quality guideline
- Reference lake surface sediments 2015 – No lakes above soil quality guideline

Zinc

This metal was <u>never</u> above the guidelines in samples from the headpond.

- Headpond surface sediments 2015 – No sites above guidelines
- Headpond surface sediments 2014 – No sites above guidelines
- Headpond sediment cores 2016 - No slices above guidelines
- Reference lake surface sediments 2015 – No lakes above guidelines

<u>Polycyclic Aromatic Hydrocarbons</u>

Acenaphthylene

This PAH was <u>occasionally</u> above the ISQG for samples from the headpond.

- Headpond surface sediments 2015 – 8 of 9 sites above a guideline
    - o > ISQG at 8 sites
- Headpond surface sediments 2014 – 2 of 12 sites above a guideline
    - o > ISQG at 2 sites
- Headpond sediment cores 2016 – 3 cores with slices above a guideline
    - o > ISQG in Long Creek core at 6.0-7.0 cm and 7.0-8.0 cm
    - o > ISQG in Riverside core at 24.0-25.5 cm, 26.5-27.5 cm and 28.5-30.0 cm
    - o > ISQG in Bear Island core at 18.0-19.0 cm
- Reference lake surface sediments 2015 – All lakes above a guideline
    - o > ISQG in all four lakes

Anthracene

This PAH was <u>never</u> above the guidelines for samples from the headpond.

- Headpond surface sediments 2015 – No sites above guidelines
- Headpond surface sediments 2014 – No sites above guidelines
- Headpond sediment cores 2016 - No slices above guidelines
- Reference lake surface sediments 2015 – 3 of 4 lakes above guidelines
- > ISQG at sites Davidson Lake (site 34), Little Magaguadavic Lake (site 35) and Skiff Lake (site 36)

Benz(a)anthracene

This PAH was <u>occasionally</u> above the ISQG for samples from the headpond.

- Headpond surface sediments 2015 – 4 of 9 sites above guidelines
    - o > ISQG at 4 sites
- Headpond surface sediments 2014 – 3 of 12 sites above guidelines
    - o > ISQG at 3 sites
- Headpond sediment cores 2016 – 4 of 6 cores with slices above guidelines
    - o > ISQG in Long Creek core at all depths except 0.0-2.0 cm
    - o > ISQG in Riverside core at all depths below 24.0 cm
    - o > ISQG in Bear Island core at 9.0-10.0 cm and 18.0-19.0 cm

    - > ISQG in NB-AVN at 10.0-11.0 cm
- Reference lake surface sediments 2015 – All lakes above guidelines
    - > ISQG at Davidson Lake (site 34), Skiff Lake (site 36) and Miramichi Lake (site 38)

Benzo(a)pyrene
This PAH was <u>never</u> above the guidelines for samples from the headpond.
- Headpond surface sediments 2015 – No sites above guidelines
- Headpond surface sediments 2014 – No sites above guidelines
- Headpond sediment cores 2016 – 1 core with slice above guidelines
    - > ISQG in Bear Island core at 18.0-19.0 cm
- Reference lake surface sediments 2015 – No lakes above guidelines

Chrysene
This PAH was <u>occasionally</u> above the ISQG for samples from the headpond.
- Headpond surface sediments 2015 – No sites above a guideline
- Headpond surface sediments 2014 – 3 of 12 sites above a guideline
    - > ISQG at 3 sites
- Headpond sediment cores 2016 – 4 cores with slices above a guideline
    - > ISQG in all slices of Long Creek core
    - > ISQG in Riverside core in all slices below 24.0 cm
    - > ISQG in Snowshoe Island at 6.0-7.0 cm
    - > ISQG in Bear Island core at 9.0-10.0 cm and 18.0-19.0 cm
- Reference lake surface sediments 2015 – 3 of 4 lakes above a guideline
- > ISQG in sites Davidson Lake (site 34), Skiff Lake (site 36), and Miramichi Lake (site 38)

Fluoranthene
This PAH was <u>occasionally</u> above the ISQG for samples from the headpond.
- Headpond surface sediments 2015 – 1 of 9 sites above a guideline
    - > ISQG at 1 site
- Headpond surface sediments 2014 – 1 of 12 sites above a guideline
    - > ISQG at 1 site
- Headpond sediment cores 2016 – 3 cores with slices above a guideline
    - > ISQG in Long Creek core at 7.0-8.0 cm
    - > ISQG in Riverside core in all slices below 24.0 cm
    - > ISQG in Bear Island core at 9.0-10.0 cm and 18.0-19.0 cm
- Reference lake surface sediments 2015 – All lakes above a guideline
    - > ISQG in all lakes

Fluorene
This PAH was <u>rarely</u> above the ISQG for samples from the headpond.
- Headpond surface sediments 2015 – 2 of 9 sites above a guideline
    - > ISQG at 2 sites
- Headpond surface sediments 2014 – No sites above a guideline
- Headpond sediment cores 2016 – No cores with slices above a guideline
- Reference lake surface sediments 2015 – 3 of 4 lakes above a guideline
    - > ISQG in Skiff Lake (site 36), Little Magaguadavic Lake (site 35), and Miramichi Lake (site 38)

Phenanthrene

This PAH was <u>often</u> above the ISQG for samples from the headpond.

- Headpond surface sediments 2015 – 8 of 9 sites above a guideline
    - > ISQG at 8 sites
- Headpond surface sediments 2014 – 4 of 12 sites above a guideline
- Headpond sediment cores 2016 – 3 cores with slices above a guideline
    - > ISQG in Long Creek core at 2.0-3.0 cm, 3.0-4.0 cm and 7.0-8.0 cm
    - > ISQG in Riverside core at in all slices below 25.5 cm
    - > ISQG in Bear Island core at 9.0-10.0 cm and 18.0-19.0 cm
- Reference lake surface sediments 2015 – All lakes above a guideline
    - > ISQG in Skiff Lake (site 36), Little Magaguadavic Lake (site 35), and Miramichi Lake (site 38)
    - > PEL at Davidson Lake (site 34)

Pyrene

This PAH was <u>often</u> above the ISQG for samples from the headpond.

- Headpond surface sediments 2015 – 6 of 9 sites above a guideline
    - > ISQG at 6 sites
- Headpond surface sediments 2014 – 10 of 12 sites above a guideline
    - > ISQG at 10 sites
- Headpond sediment cores 2016 – All cores with slices above a guideline
    - > ISQG in Long Creek core at all depths
    - > ISQG in Riverside core at 4.0-5.5 cm and all depths below 24.0 cm
    - > ISQG in Snowshoe Island core at 6.0-7.0 cm
    - > ISQG in Bear Island core at all slices (0.0-1.0 cm, 9.0-10.0 cm and 18.0-19.0 cm)
    - > ISQG in NB-AVN at 0.0-1.0 cm and 10.0-11.0 cm
    - > ISQG in AVN-UP at 0.0-1.0 cm and 8.0-9.0 cm
- Reference lake surface sediments 2015 – All lakes above a guideline
    - > ISQG in all lakes

Total PAHs

Total PAHs were <u>never</u> above guidelines samples from the headpond.

- Headpond surface sediments 2015 – No sites above guideline
- Headpond surface sediments 2014 – No sites above guideline
- Headpond sediment cores 2016 – No cores with slices above guideline
- Reference lake surface sediments 2015 – 1 lake above a guideline
    - > ISQG at Skiff Lake (site 36)

<u>Chlorinated Pesticides</u>

γ - HCH (Lindane)

This pesticide was <u>never</u> above guidelines for samples from the headpond.

- Headpond surface sediments 2015 – No sites above guidelines
- Headpond surface sediments 2014 – No sites above guidelines
- Headpond sediment cores 2016 – No cores with slices above guidelines
- Reference lake surface sediments 2015 – 1 lake above guidelines

    - > ISQG in Davidson Lake (site 34)

Heptachlor epoxide
This pesticide was <u>never</u> above guidelines for samples from the headpond.

- Headpond surface sediments 2015 – No sites above guidelines
- Headpond surface sediments 2014 – No sites above guidelines
- Headpond sediment cores 2016 – No cores with slices above guidelines
- Reference lake surface sediments 2015 – No lakes above guidelines

Dieldrin
This pesticide was <u>never</u> above guidelines for samples from the headpond.

- Headpond surface sediments 2015 – No sites above guidelines
- Headpond surface sediments 2014 – No sites above guidelines
- Headpond sediment cores 2016 – No cores with slices above guidelines
- Reference lake surface sediments 2015 – No lakes above guidelines

Endrin
This pesticide was <u>never</u> above guidelines for samples from the headpond.

- Headpond surface sediments 2015 – No sites above guidelines
- Headpond surface sediments 2014 – No sites above guidelines
- Headpond sediment cores 2016 – No cores with slices above guidelines
- Reference lake surface sediments 2015 – No lakes above guideline

ΣChlordane
This pesticide was <u>never</u> above guidelines for samples from the headpond.

- Headpond surface sediments 2015 – No sites above guidelines
- Headpond surface sediments 2014 – No sites above guidelines
- Headpond sediment cores 2016 – No cores with slices above guidelines
- Reference lake surface sediments 2015 – No lakes above guideline

ΣDDE
This pesticide <u>often</u> above ISQG and PEL guidelines for samples from the headpond.

- Headpond surface sediments 2015 – All sites above a guideline
    - > ISQG in 2 sites
    - > PEL in 7 sites
- Headpond surface sediments 2014 – All sites above guidelines
    - > ISQG in 1 site
    - > PEL in 11 sites
- Headpond sediment cores 2016 – All cores with slices above guidelines
    - > ISQG for Snowshoe Island core at 0.0-2.0 cm and 11.0-12.0 cm
    - > ISQG for AVN-UP at 8.0-9.0 cm and 17.0-18.0 cm
    - > PEL for all slices from Long Creek core
    - > PEL for all slices from Riverside core
    - > PEL for Snowshoe Island core at 6.0-7.0 cm
    - > PEL for all slices from Bear Island
    - > PEL for all slices from NB-AVN
    - > PEL for AVN-UP at 0.0-1.0 cm

- Reference lake surface sediments 2015 – All lakes above guidelines
    - > ISQG for sites Little Magaguadavic Lake (site 35) and Skiff Lake (site 36)
    - > PEL for Davidson Lake (site 34) and Miramichi Lake (site 38)

ΣDDD

This pesticide <u>often</u> above ISQG and PEL guidelines for samples from the headpond.

- Headpond surface sediments 2015 – 7 of 9 sites above guidelines
    - > ISQG in 5 sites
    - > PEL in 2 sites
- Headpond surface sediments 2014 – 11 of 12 sites above guidelines
    - > ISQG in 4 sites
    - > PEL in 7 sites
- Headpond sediment cores 2016 – All cores with slices above guidelines
    - > ISQG for all slices from Riverside core between 0.0-4.0 cm and 5.5-8.5 cm
    - > ISQG for NB-AVN core at 0.0-1.0 cm and 22.0-23.0 cm
    - > ISQG for AVN-UP core at 0.0-1.0 cm
    - > PEL for all slices from Long Creek core
    - > PEL for all slices from Riverside 4.0-5.5 cm and core below 24.0 cm
    - > PEL for Snowshoe Island core at 6.0-7.0 cm
    - > PEL for all slices from Bear Island
    - > PEL for NB-AVN core from 10.0-11.0 cm
- Reference lake surface sediments 2015 – All lakes above guidelines
    - > ISQG for Skiff Lake (site 36)
    - > PEL for sites Davidson Lake (site 34) and Miramichi Lake (site 38)

ΣDDT

This pesticide <u>often</u> above ISQG and PEL guidelines for samples from the headpond.

- Headpond surface sediments 2015 – 8 of 9 sites above a guideline
    - > ISQG in 3 sites
    - > PEL in 5 sites
- Headpond surface sediments 2014 – 12 of 12 sites above guidelines
    - > ISQG in 1 sites
    - > PEL in 11 sites
- Headpond sediment cores 2016 – All cores with slices above guidelines
    - > ISQG for all slices from Riverside core between 4.0-5.5 cm, 5.5-7.0 cm, 7.0-8.5cm, 24.0-25.5 cm and 28.5-30.0 cm
    - > ISQG for Snowshoe Island core at 0.0-2.0 cm and 11.0-12.0 cm
    - > ISQG for AVN-UP core at 17.0-18.0 cm
    - > PEL for all slices from Long Creek core
    - > PEL for Riverside core slices at 0.0-2.0 cm, 2.0-4.0 cm, 25.5-26.5 cm, 26.5-27.5 cm, and 27.5-28.5 cm
    - > PEL for Snowshoe Island core at 6.0-7.0 cm
    - > PEL for all slices from Bear Island core
    - > PEL for all slices from NB-AVN core
    - > PEL for AVN-UP core from 0.0-1.0 cm and 8.0-9.0 cm
- Reference lake surface sediments 2015 – 2 lakes above guidelines
    - > ISQG for Davidson Lake (site 34) and Miramichi Lake (site 38)

Total PCBs

Total PCBs were <u>never</u> above guidelines for samples from the headpond.

- Headpond surface sediments 2015 – No sites above guidelines
- Headpond surface sediments 2014 – No sites above guidelines
- Headpond sediment cores 2016 – No cores with slices above guidelines
- Reference lake surface sediments 2015 – No lakes above guidelines

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