Canada-Newfoundland and Labrador
Water Quality Monitoring Agreement

Assessment of Wastewater Impacts in the Churchill River near Happy Valley-Goose Bay

March 2010

Newfoundland Labrador

Canada

Acknowledgements

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Thanks to:

Newfoundland and Labrador Department of Natural Resources – Forestry Services Branch
Water Survey of Canada
Atlantic Laboratory for Environmental Testing
National Laboratory for Environmental Testing
St. John's Laboratory
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Executive Summary

An assessment of wastewater impacts in the Churchill River near Happy Valley – Goose Bay (HV-GB) in Labrador was completed in the summer of 2008, as part of the Canada – Newfoundland and Labrador Water Quality Monitoring Agreement (WQMA). The study was designed to provide a general understanding of the extent and level of impact from the two sewage outfalls from the Town of HV-GB in water, sediment, and biota. Results only reflect conditions observed during the one-week sampling period and do not consider conditions under different seasonal flow conditions and other weather events.

The Town of HV-GB had two municipal wastewater outfalls that discharge untreated wastewater directly to the Churchill River in August 2008. The first outfall was located at the eastern end of Birch Island and the second outfall was located downstream near the intersection of Hamilton Road and Corte Real Road. Several upstream activities that could potentially affect water quality in the HV-GB were considered in relation to local wastewater impacts. These included mining activities, municipal and industrial wastewaters, hydroelectric projects, and the remediation work at 5 Wing Goose Bay.

The Churchill River near HV-GB supports aquatic life, is used for recreation (boating, swimming, etc.), and supplies water for limited agricultural activities. Recreational water use was considered to be a main priority as it relates directly to human health risks associated with untreated sewage in the area.

The following are the main conclusions of the study:

- Exceedances of the CCME recreational water use guidelines were observed for fecal coliforms in the Churchill River near HV-GB. Elevated fecal coliform concentrations were found downstream of the two sewage outfalls and are consistent with impacts expected downstream of raw sewage outfalls. Examination of the spatial pattern in fecal coliform concentrations indicate that the sewage impacts are not readily diluted by the large volumes of water within the Churchill River.

- Water sampling identified aluminum and iron concentrations that exceed the CCME Guidelines for the Protection of Aquatic Life – Freshwater. Elevated aluminum and iron concentrations are associated with suspended matter and are typical of Newfoundland and Labrador waters. Concentrations were consistent at all sampling locations and are not likely related to wastewater impacts. High levels of aluminum and iron have been recorded at the Upper Muskrat Station over the past thirty years with average aluminum and iron concentrations at this station exceeding CCME Guidelines (Envirodat, 2009).

- Water quality results for general chemistry, metals, and organics do not indicate a major change in water chemistry in the Churchill River from wastewater inputs in downstream reaches compared to upstream reaches above the two outfalls. Localized minor changes in major ion ratios, specific conductance and temperature give an indication of the dispersion patterns of the wastewater within the river in the vicinity of the outfalls. The key indicator parameters for wastewater inputs from the two sewage outfalls were fecal coliforms, major ion ratios, specific conductance and temperature.

- The sediment sampling did not identify impacts directly attributable to wastewater impacts in the immediate study area. Deposition of suspended material associated with wastewater impacts in downstream areas (e.g. Lake Melville) may locally impact aquatic ecosystems but this was beyond the scope of this assessment.

- Organic contaminants were detected in biota but the source and extent of these contaminants could not be determined based on the minimal samples collected. However, observed impacts (e.g. elevated PCBs and OC pesticides – specifically DDT) in the biota are more consistent with bio-accumulation from atmospheric pollutants and from activities upstream of the outfalls.

- By mapping the identified indicator parameters, a general understanding of the dispersion of the wastewater within the study area has been obtained. Wastewater is discharged from the two outfalls but does not readily mix with the flowing water. Results from the cruise data (Figure 4) and the spatial distribution of the fecal coliforms concentrations (Figure 6) indicate that impacts from wastewater and ultimately the fecal coliform concentrations are higher along the shore where velocities are lower than in the main channel. This further supports the findings of the longer term fecal coliform monitoring conducted by the province of Newfoundland and Labrador from 1981 to 1988 that consistently found higher concentrations along shore areas and in shallower areas downstream of the outfalls (NDEL, 1989).

- The Lower Outfall (Corte Real Road) is located in a deeper channel (> 10 metres at the time of study) which allows for more mixing and dilution of the wastewater. As a result, the impacts from the Lower Outfall appear to be less than from the upper outfall (Birch Island Outfall) where the flow velocities are lower and the river depth at the time of sampling was shallower (1.5 metres at NF03OE0043) thereby reducing the dilution and dispersion effects.

- Based on the results of this study, it was possible to identify two potential zones of impacts from the wastewater. Zone A (Figure 7) is located in the vicinity of the two outfalls and in the immediate downstream sections. Zone A represents an area where fecal coliforms measured exceeded the CCME guideline for recreational water use. Zone B (Figure 7) is an area downstream of Zone A where the potential for impacts from the wastewater (including exceedances of the recreational guideline) exists given the observed dispersion characteristics of the wastewater into the Churchill River near HV-GB. Zone B ends at the eastern edge of the study area at NF03OE0048. Areas to the east of NF03OE0048 may still have the potential for wastewater impacts but these areas were not studied during this assessment.

- Recreational water use, primarily associated with boating, occurs in areas downstream of the two sewage outfalls. Therefore, the potential for impaired recreational water use is greatest downstream of the outfalls and to the north of the main river channel (i.e. the main channel where discharge volume is greatest at deepest and highest flow velocities). Fecal coliforms are also an indicator of other water borne pathogens that commonly occur in untreated wastewater as well as many new and emerging contaminants (e.g. pharmaceutical and personal care products).

The following recommendations are provided based on the conclusions of the 2008 study:

- The ongoing discharge of untreated wastewater directly into the Churchill River has environmental and human health impacts, particularly with regard to bacterial contamination of the receiving waters. This impact has the potential to adversely impact both the environment at large and the health of the people using the impacted area for water-based recreational activities. Therefore the Town of HV-GB should move forward with building a sewage treatment system capable of removing solids and reducing pathogenic bacteria concentrations in the receiving waters. Furthermore, the treatment system should have an outlet into the Churchill River that should be located to optimize dilution and dispersion into the river.

- The two identified zones of concern should have management plans developed to minimize any risk to human health for people living in the area or for those who use the area for recreational activities (e.g. boating). At a minimum, Zone A should be restricted for swimming and wading and/or any activity requiring direct contact with the water (e.g. fishing). Boaters should be warned to avoid direct contact with water in this zone and to take necessary precautions. In Zone B all users should be warned to minimize contact with water and take precautionary measures to reduce the risk to human health.

- Additional signage should be erected to notify residents of the boundaries of the two zones of concern and restricted activities.

- An education program should be initiated to inform residents about the risks of contact with water impacted by raw sewage and also to identify precautions to take should contact with water be required. This program could include public information sessions, posters, pamphlets and signage.

- An ongoing monitoring program should be carried out to ensure conditions do not worsen. Such a monitoring program would involve collecting samples at regular sampling sites several times per year. The monitoring program should include sampling for fecal coliforms as these are the main indicator of wastewater impacts and are also the parameter that has an established guideline for recreational water use. This sampling program could be used to better define the zones of impact and any changes over time due to changes in river morphology.

- If a treatment system is built, monitoring of treated wastewater should adhere to the applicable guidelines and the zone of impacts should be re-defined based on treatment system design and effluent quality.

Sommaire

Une étude des impacts des eaux usées dans la rivière Churchill près de Happy Valley-Goose Bay (HV-GB) au Labrador a été achevée au cours de l'été 2008, dans le cadre de l'Accord Canada–Terre-Neuve-et-Labrador sur le monitoring de la qualité des eaux. L'étude a été conçue pour donner une vue d'ensemble de l'étendue et de l'ampleur de l'impact des eaux usées provenant des deux émissaires d'évacuation de la ville de HV-GB dans l'eau, les sédiments et le biote. Les résultats reflètent seulement les conditions observées pendant la semaine d'échantillonnage et ne tiennent pas compte des conditions sous différents régimes d'écoulement saisonnier et autres évènements météorologiques.

En août 2008, la ville de HV-GB disposait de deux émissaires d'évacuation déversant des eaux usées municipales non traitées directement dans la rivière Churchill. Le premier émissaire était situé à l'extrémité est de l'île Birch et le second, en aval près de l'intersection de Hamilton Road et de Corte Real Road. Plusieurs activités en amont qui auraient eu le potentiel d'affecter la qualité de l'eau à HV-GB ont été considérées en relation avec les impacts locaux des eaux usées. Celles-ci comprenaient les activités minières, les rejets d'eaux usées municipales et industrielles, les projets hydroélectriques et les travaux de restauration à la 5^{e} Escadre Goose Bay.

La rivière Churchill près de HV-GB soutient la vie aquatique, est utilisée à des fins récréatives (navigation de plaisance, nage, etc.) et procure l'eau pour un nombre limité d'activités agricoles. L'utilisation de l'eau à des fins récréatives a été considérée comme étant une priorité principale puisqu'elle se rattache directement aux risques sur la santé humaine associés à la présence d'eaux usées dans la région.

Voici les principales conclusions de l'étude :

- Des dépassements des recommandations du Conseil canadien des ministres de l'environnement (CCME) en ce qui concerne les eaux utilisées à des fins récréatives ont été observés pour les coliformes fécaux dans la rivière Churchill près de HV-GB. Des concentrations élevées de coliformes fécaux ont été relevées en aval des deux émissaires d'évacuation et sont cohérentes avec les impacts prévus en aval d'émissaires d'eaux usées non traitées. L'examen de la répartition spatiale des concentrations de coliformes fécaux indique que les effets des eaux usées ne sont pas instantanément dilués par l'important volume d'eau que transporte la rivière Churchill.

- L'échantillonnage de l'eau a permis de trouver des concentrations d'aluminium et de fer qui dépassent les Recommandations canadiennes pour la qualité des eaux : protection de la vie aquatique (eau douce). Les

concentrations élevées d'aluminium et de fer sont associées aux matières en suspension et sont typiques des eaux de Terre-Neuve-et-Labrador. Les concentrations étaient constantes à tous les points d'échantillonnage et ne sont probablement pas reliées aux effets des eaux usées. Des concentrations élevées d'aluminium et de fer ont été enregistrées à la station Upper Muskrat au cours des 30 dernières années, les concentrations moyennes de ces substances mesurées à cette station dépassant les recommandations du CCME (Envirodat, 2009).

- Les résultats liés à la qualité de l'eau obtenus pour les paramètres chimiques généraux, les métaux et les composés organiques n'indiquent aucun changement majeur dans la composition chimique de l'eau de la rivière Churchill qui soit attribuable aux entrées d'eaux usées dans les tronçons en aval comparativement aux tronçons en amont des deux émissaires d'évacuation. Des changements mineurs et localisés dans les bilans ioniques, la conductivité spécifique et la température donnent un indice du tracé de dispersion des eaux usées dans la rivière à proximité des émissaires. Les paramètres indicateurs clés de l'entrée d'eaux usées par les deux émissaires d'évacuation étaient les coliformes fécaux, les bilans ioniques, la conductivité et la température.

- L'échantillonnage des sédiments n'a pas permis de déterminer des impacts directement attribuables aux effets des eaux usées dans l'aire d'étude immédiate. Le dépôt de matières en suspension associé aux effets des eaux usées dans les secteurs en aval (p. ex. lac Melville) peut nuire localement aux écosystèmes aquatiques; l'examen de cette question dépassait toutefois la portée de la présente étude.

- Des contaminants organiques ont été détectés dans le biote, mais il était impossible de déterminer la source et l'étendue de ces contaminants à partir du peu d'échantillons recueillis. Toutefois, les impacts observés (causés par exemple par des concentrations élevées de biphényles polychlorés [BPC] et de pesticides organochlorés – spécifiquement de dichlorodiphényltrichloroéthane [DDT]) dans le biote sont davantage cohérents avec l'accumulation biologique provenant des polluants atmosphériques et des activités anthropiques en amont des émissaires.

- En projetant sur une carte les paramètres indicateurs identifiés, une compréhension générale de la dispersion des eaux usées à l'intérieur de la zone d'étude a été obtenue. Les eaux usées sont évacuées à partir des deux émissaires d'évacuation, mais elles ne se mélangent pas instantanément avec l'eau de la rivière. Les résultats des données provenant de la croisière (figure 4) et la distribution spatiale des concentrations de coliformes fécaux (figure 6) indiquent que les impacts des eaux usées et, en fin de compte, les concentrations de coliformes fécaux sont plus élevés le long de la rive où les vitesses sont inférieures à celles dans le chenal principal. Cette affirmation vient étayer davantage les conclusions du monitoring à plus long terme des coliformes fécaux effectué par la province de Terre-Neuve-et-Labrador entre 1981 et 1988 qui a constamment relevé des concentrations plus élevées près des aires riveraines et dans les secteurs moins profonds en aval des émissaires (NDEL, 1989).

- Le plus bas des deux émissaires (Corte Real Road) est situé dans un canal plus profond (plus de 10 mètres au moment de l’étude), ce qui permet de mélanger et de diluer davantage les eaux usées. En conséquence, les impacts provenant de l’émissaire plus bas semblent être moins importants que ceux provenant de celui situé plus haut (île Birch) où les vitesses d’écoulement sont inférieures et la profondeur de la rivière au moment de l’échantillonnage était moindre (1,5 mètre à la station NF03OE0043) réduisant ainsi les effets de dilution et de dispersion.

- À partir des résultats de cette étude, il a été possible de déterminer deux zones potentielles d’impact par les eaux usées. La zone A (figure 7) est située à proximité des deux émissaires et dans les sections immédiatement en aval. Elle représente une aire où les coliformes fécaux mesurés excédaient la recommandation du CCME pour l’eau utilisée à des fins récréatives. Quant à la zone B (figure 7), il s’agit d’une aire en aval de la zone A où les eaux usées peuvent être à l’origine d’impacts (y compris de dépassements des recommandations pour l’eau utilisée à des fins récréatives) étant donné les caractéristiques de dispersion des eaux usées observées dans la rivière Churchill près de HV-GB. La zone B finit à l’extrémité est de l’aire d’étude à la station NF03OE0048. Des aires à l’est de cette station sont toujours susceptibles de subir les impacts des eaux usées, mais elles n’ont pas été examinées dans le cadre de cette étude.

- L’eau utilisée à des fins récréatives, principalement pour la navigation de plaisance, se trouve en aval des deux émissaires d’évacuation des eaux usées. Ainsi, le potentiel de détérioration des eaux utilisées à des fins récréatives est plus grand en aval des émissaires ainsi qu’au nord du lit principal de la rivière (c.-à-d. le chenal principal où le volume d’écoulement est maximal dans les zones les plus profondes et où la vitesse de l’écoulement est maximale). Les coliformes fécaux servent également d’indicateur pour d’autres pathogènes d’origine hydrique qui se trouvent communément dans les eaux usées non traitées ainsi que pour nombre de contaminants nouveaux et émergents (p. ex. produits pharmaceutiques et produits de soins personnels).

Voici les recommandations formulées d’après les conclusions le l’étude de 2008 :

- Le déversement continuel d'eaux usées non traitées directement dans la rivière Churchill a des impacts sur l'environnement et la santé humaine, particulièrement en ce qui concerne la contamination bactériologique des eaux réceptrices. Cet impact pourrait nuire à l'environnement en général et à la santé des gens pratiquant des activités aquatiques récréatives dans la zone touchée. Ainsi, la ville de HV-GB devrait aller de l'avant avec la construction d'un système de traitement des eaux usées capable de soustraire les solides et de réduire les concentrations de bactéries pathogènes dans les eaux réceptrices. De plus, le système de traitement devrait avoir un exutoire dans la rivière Churchill qui devrait être situé de façon à optimiser la dilution et la dispersion dans la rivière.

- Des plans de gestion devraient être établis pour les deux zones préoccupantes identifiées afin de minimiser tout risque à la santé humaine pour les gens qui vivent à proximité ou pour ceux qui utilisent cette zone pour des activités récréatives (p. ex. navigation de plaisance). À tout le moins, il faudrait interdire la natation, le barbotage et/ou toute activité exigeant un contact direct avec l'eau (p. ex. la pêche) dans la zone A. Les plaisanciers devraient être avertis d'éviter le contact direct avec l'eau dans cette zone et de prendre les précautions nécessaires. Dans la zone B, tous les utilisateurs devraient être avertis de limiter le contact avec l'eau et de prendre des mesures préventives afin de réduire les risques liés à la santé humaine.

- Des panneaux de signalisation additionnels devraient être installés pour informer les résidents des limites des zones préoccupantes et des activités restreintes.

- Un programme éducatif devrait être lancé pour informer les résidents des risques d'entrer en contact avec de l'eau contaminée par des eaux usées non traitées et aussi pour déterminer les précautions à prendre si le contact avec l'eau est nécessaire. Ce programme pourrait inclure des séances d'information publiques, des affiches, des brochures et des panneaux de signalisation.

- Un programme de monitoring permanent devrait être exécuté pour veiller à ce que les conditions ne s'aggravent pas. Un tel programme nécessiterait la collecte d'échantillons à des sites d'échantillonnage réguliers plusieurs fois par année. Le programme de monitoring devrait inclure un échantillonnage afin de déceler la présence des coliformes fécaux, car ils constituent le principal indicateur des impacts des eaux usées et représentent également le paramètre pour lequel il existe une recommandation pour l'utilisation de l'eau à des fins récréatives. Ce programme d'échantillonnage pourrait servir à mieux définir les zones d’impact et tout changement dans le temps causé par des modifications de la morphologie de la rivière.

- Si un système de traitement est construit, le monitoring des eaux usées traitées devrait adhérer aux recommandations pertinentes et la zone d’impact devrait être redéfinie en fonction de la conception du système de traitement et de la qualité de l’effluent.

Table of Contents

List of Figures

List of Photos

1 Introduction

The Government of Canada and the province of Newfoundland and Labrador have operated a federal-provincial water quality monitoring agreement since 1986. Under this agreement, water quality monitoring is conducted for the assessment and protection of water resources in Newfoundland and Labrador in a co-ordinated and cost-shared manner by the two levels of government. In addition to the routine monitoring conducted under this agreement, targeted monitoring has also been completed that serves to assess specific water quality issues at the watershed level. These surveys have historically been referred to as ‘intensive’ or ‘recurrent’ surveys depending on the nature of the survey. This report includes the results of an intensive survey on the Churchill River in the Happy Valley – Goose Bay (HV-GB) region of Labrador to assess local wastewater impacts.

1.1 Study Objectives

The main objective of this study was to assess municipal wastewater impacts in the Churchill River in the HV-GB region of Labrador. The study was designed to provide a general understanding of the extent and level of impact from the two sewage outfalls from the Town of HV-GB in water, sediment, and biota. The desired outcomes of the assessment are to provide recommendations that would minimize human health effects from municipal wastewater discharges in the Churchill River and protect and improve aquatic ecosystem health.

1.2 Background Information

1.2.1 Churchill River Basin Characteristics

The Churchill River is located in Labrador (Figure 1) and is the largest river within the province of Newfoundland and Labrador. Figure 1 has the Churchill River drainage area highlighted in light green. The river has a drainage basin that is approximately 94,000 square kilometres (km^2) and has a mean annual flow of 1740 cubic metres per second (m^3/sec) at Muskrat Falls which is approximately 25 kilometres upstream of HV-GB. Significant alterations have been made in the upper watershed to provide for hydroelectric generation at the Churchill Falls Generating Station (CANAL, 2009).

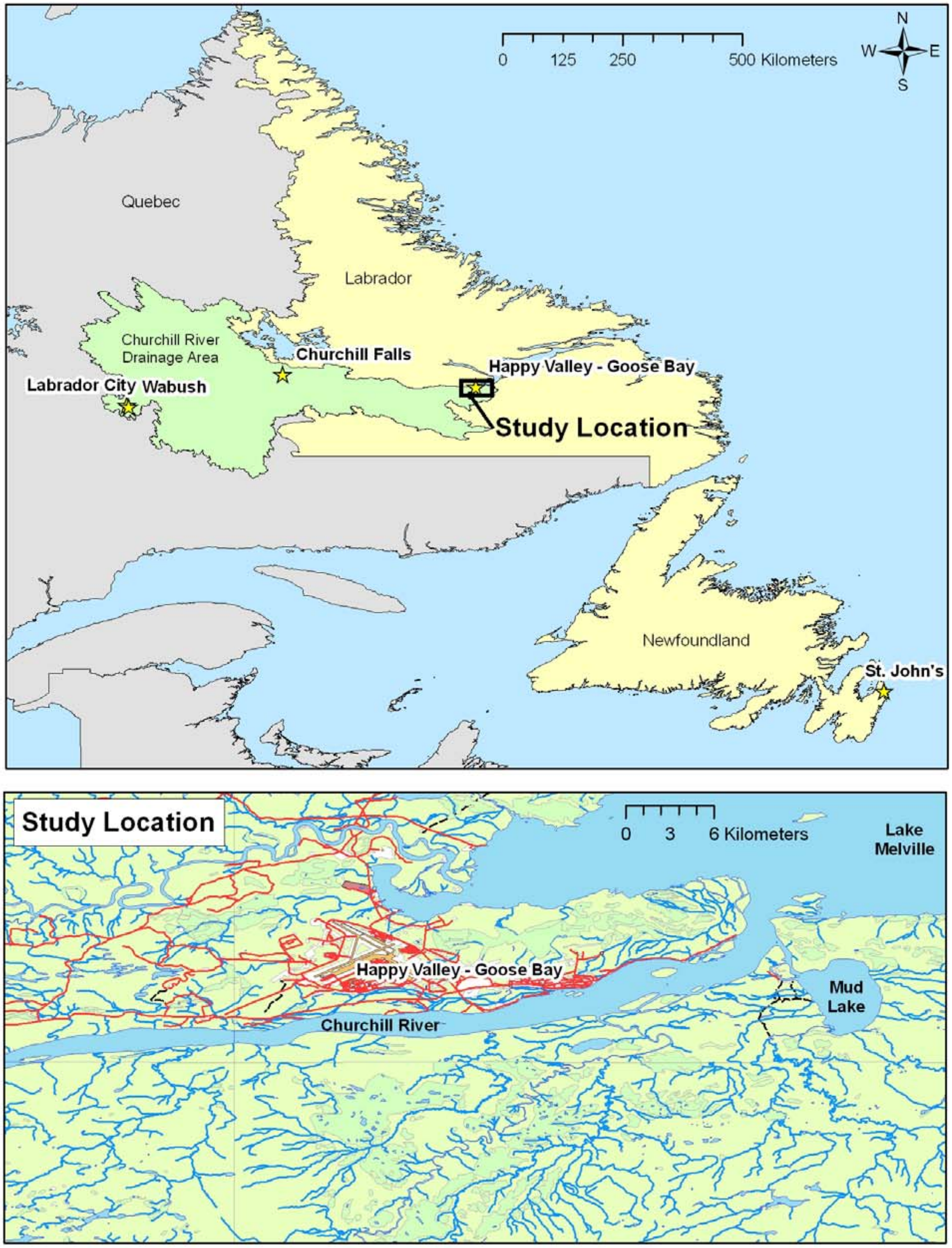


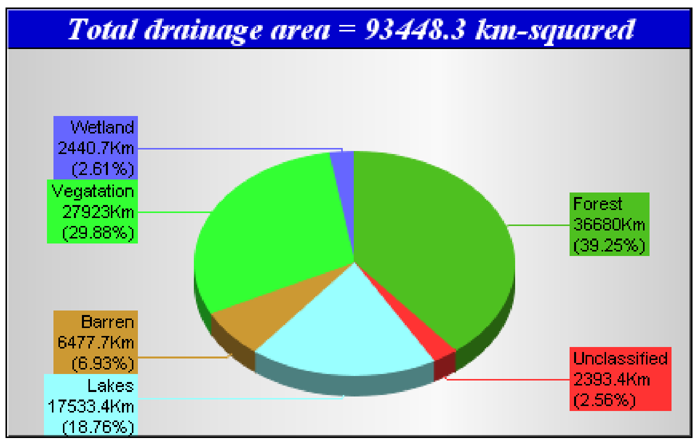
Figure 1 - Study Location

The Churchill River drainage area is located within the Boreal Shield and Taiga Shield ecozones. The majority of the drainage area is underlain by the Canadian Shield bedrock with a coniferous forest cover. The Boreal Shield ecozones are typically found in the lower reaches of the valley that are more sheltered. The Taiga Shield regions are found in the northern sections of the drainage area and also in the upland sections of the valley. The Taiga Shield represents the transition from the Boreal ecosystems to the Arctic ecosystems found in northern Labrador.

The western part of the basin consists of flat to rolling plateaus. Broad river valleys and rolling hills characterize the eastern part of the basin. Drumlins and eskers are characteristic throughout the basin. The river reaches through HV-GB are characterized by deltaic sand sediments.

Upstream of Muskrat Falls, the river system is straight to sinuous and flows within a single wandering channel. Downstream of Muskrat Falls, the river system changes to a braided system. Multiple channels form within the river system and banks are easily eroded due to the deltaic sand sediments present. This active erosion contributes suspended sediment to the river which results in decreased clarity of the river near HV-GB.

Figure 2 - Land Cover - Churchill River at Muskrat Falls



Source: CANAL, 2009

Figure 2 shows the distribution of land cover within the drainage area upstream of Muskrat Falls. Land cover is predominantly forest and vegetation comprising about 69.1 % of the drainage area. Lakes account for approximately 18.8 % of the drainage area while wetlands cover about 2.6 % (CANAL, 2009).

Water quality at the long term monitoring station at Muskrat Falls (NF03OE0001) was ranked excellent (for the protection of aquatic life) for the sample period 2004 to 2006 using the CCME water quality index (WQI) (NL DOEC, 2008). The station's WQI was not reported under the Canadian Environmental Sustainability Indicators 2008 report due to a low sampling frequency (i.e. less than 3 samples per year) but has been reported in previous years. Low sampling frequencies are common in Canada's North as remoteness of stations and travel costs are limiting factors.

An overview of general water quality at the Muskrat Falls long term monitoring (NF03OE0001) station for the last 10 years is provided in the following Table 1.

In general, the water is a dilute (median specific conductance 19.2 µS/cm), calcium bicarbonate type water that has near neutral pH (median pH 6.83). Median concentrations of total nitrogen (0.15 mg/L) and total phosphorus (0.014 mg/L) are low indicating nutrient poor conditions. Higher concentrations of total phosphorus (maximum 0.062 mg/L) are commonly measured during snowmelt periods (i.e. March/April).

Table 1 - General Water Quality - Churchill River at Muskrat Falls (1997-2007)

Parameter	Units	Count	Minimum	Maximum	Median
Sodium	**mg/L**	40	0.42	1.14	**0.63**
Potassium	**mg/L**	40	0.10	0.56	**0.32**
Calcium	**mg/L**	40	1.08	2.90	**2.07**
Magnesium	**mg/L**	40	0.33	0.89	**0.72**
Alkalinity	**mg/L as $CaCO_3$**	29	4.85	8.86	**7.15**
Chloride	**mg/L**	41	0.20	0.95	**0.30**
Sulphate	**mg/L**	40	0.08	1.74	**0.92**
Nitrate	**mg/L as N**	40	<0.01	0.05	**0.02**
Total Nitrogen	**mg/L**	39	0.03	0.23	**0.15**
Total Phosphorus	**mg/L**	40	0.003	0.062	**0.014**
Specific Conductance	**µS/cm**	41	11.1	29.7	**19.2**
pH	**pH units**	41	6.15	7.31	**6.83**
Source: Envirodat, 2009					

1.2.2 Study Area Characteristics

The study area encompassed the section of the river from Muskrat Falls to Goose Bay at the head of Lake Melville. The study area section is presented on Figure 1. The Town of HV-GB is located on the north bank of the Churchill River. The town had a population of approximately 6,500 people in the 2006 census (SC, 2006) and is the largest community at the eastern end of the Churchill River. The study concentrated on the area around the two sewage outfalls and in the upstream and downstream sections of the Churchill River within a 10-15 kilometre radius. A large military base, 5 Wing Goose Bay is located on the north bank of the Churchill River and upstream of the two sewage outfalls.

Swifter river currents were present in the main channel of the river where the depth of water was measured at greater than 18 metres in some areas (e.g. under the Trans Labrador Highway bridge). Eddies, water currents moving in different directions to the main flow and usually slower, were visible in shallower sections and behind significant depositional features, such as islands. A notable eddy was visible downstream and adjacent to the Lower Outfall at Corte Real Road.

Sediments within the study area were fairly homogeneous consisting of unconsolidated fine to medium grained sand with little vegetation or cover for aquatic life. Several small tributaries in the vicinity of Birch Island and also along the south bank of the Churchill River appeared to contain more aquatic vegetation and finer grained sediments.

1.2.3 Major Activities in the Churchill River Basin Potentially Affecting Water Quality

Despite the fact that the Churchill River basin is large and has an extremely small population density, there are several activities in the drainage area that have the potential to affect water quality. Some of the major activities that potentially affect water quality in the study area are discussed briefly in the following sections.

1.2.3.1 Mining

Mining activities in the Churchill River Basin are concentrated in the upper drainage basin in the vicinity of Wabush and Labrador City. The majority of mining is iron ore mining. Several large open pit mines are currently in operation with associated rock tailings piles in the upper reaches of the Churchill River drainage area. Impacts from mining activities typically differ from municipal wastewater impacts and therefore influence from mining activities upstream were not expected to alter water quality in the study area portion of the river as it relates to the assessment of municipal wastewater discharge near HV-GB.

1.2.3.2 Urban and Suburban Development

The population within the Churchill River basin is relatively small in comparison to the large drainage area size. People are generally concentrated in several larger communities that have municipal wastewater services. The potential exists for wastewater impacts from these communities to be present downstream at the study site. However, given the estimated wastewater loads and the discharge (mean annual discharge 1740 m^3/sec) of the Churchill River near HV-GB, it would be difficult to detect any significant impact to water quality at the study site from these upstream communities. Municipal wastewater discharges are discussed further in Section 1.2.4.

1.2.3.3 Hydroelectric Generation

The Churchill Falls Generating Station currently generates approximately 5,400 megawatts (MW) of power and represents about two-thirds of the hydroelectric potential of the Churchill River. The proposed Lower Churchill project predicts an additional capacity of 2,800 MWs could be derived from installations at Gull Island and Muskrat Falls (NL Hydro, 2006). At the time of the study, no earthworks had been undertaken for this project that would have the potential to impact water quality in the study area.

The creation of a large reservoir (i.e. the Smallwood Reservoir) during the initial construction of the Churchill Falls Generating station may have altered concentrations of certain contaminants (e.g. increased mercury) in water, sediment, and biota. As well, the reservoir may act as a sink for nutrients and sediment that may have normally been transported down the original river channel. Water quality is expected to be less variable downstream of the reservoir under normal flow conditions as it is more characteristic of water quality exiting a large lake.

1.2.3.4 Transportation Corridors

The Trans Labrador Highway is the major transportation link between HV-GB and Labrador City and ultimately to the province of Quebec. The highway construction was in Phase III at the time of the study and involved linking HV-GB to Cartwright Junction. Phase III involved construction of a causeway and a bridge structure (Photo 1) across the Churchill River approximately 12 kilometres upstream of HV-GB.

Photo 1 – Trans Labrador Highway Bridge and Causeway over Churchill River

Construction on Phase III of the Trans Labrador Highway was taking place at the time of the study in the region south of the Churchill River. The bridge was completed at the time of the study but was not yet open to the public.

1.2.3.5 5 Wing Goose Bay Remediation Project

A project description for the remediation of 5 Wing Goose Bay, a former USAF military base now operating as a Canadian Forces Base (CFB), has been prepared under the *Canadian Environmental Assessment Act* (DND, 2008). The proposed remediation will address historical contamination on the military base and on adjoining properties impacted by activities on the base. Heavy metals and other contaminants such as polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) are due to historical waste disposal practices and the existence of numerous dumpsites associated with activities on the base (DND, 2008). Detectable concentrations of these contaminants have been found in sediment, soil, surface water, groundwater and biota in the vicinity of the base as well as other locations within the HV-GB area. Therefore, there is a potential for these contaminants to affect water quality within the study area.

For the purposes of this report, it was realized that it may be difficult to separate contaminant sources to the Churchill River and this is discussed in more detail in Section 2.1. It should be noted that the majority of the base is located in a separate drainage area (Goose River and Terrington Basin/Lake Melville basin) to the north of the Churchill River basin. However, surface water from the southern edge of the base does enter the Churchill River through Spring Gulch Brook. Groundwater discharge also provides recharge to small streams and wetlands along the southern edge of the base that flow to the Churchill River.

1.2.4 Wastewater Discharges in the Churchill River Basin

In order to assess the impact of municipal wastewater on the Churchill River from the Town of HV-GB, it was necessary to identify the major releases of wastewater from upstream communities. There are several discharges of wastewater within the Churchill River basin from various communities and also from industry.

In general, municipal wastewater upstream of HV-GB undergoes primary treatment while wastewater from the Town of HV-GB is discharged untreated to the Churchill River. A summary of the known municipal wastewater releases as reported by Newfoundland and Labrador Environment and Conservation in 2008 are presented in Table 2.

Table 2 – Municipal Wastewater Discharges in the Churchill River Basin

Community	Treatment Type (# of outfalls)	Water Body Receiving Discharge	Estimated Total Load (m^3/d)
Labrador City (Drake St. Treatment Plant)	Primary treatment (1)	Little Wabush Lake	3159
Labrador City (Harrie Lake Treatment Plant)	Contact stabilization treatment (1)	Harrie Lake	639
Wabush	Primary treatment (1)	Little Wabush Lake	936
Churchill Falls	Extended aeration treatment (1)	Churchill River	1668
Happy Valley-Goose Bay	No treatment (2)	Churchill River	2575[1]

Note 1 – This is an estimate produced by the province in the absence of measured flows and is based on population statistics. Lower actual flows were measured from April to November 2005 as part of Wastewater Treatment Lagoon Study (BAE Newplan Group Limited, 2006) and are discussed in Section 1.2.5.
Source: Wastewater Treatment System Inventory (NL DOEC, 2008)

As mentioned in Section 1.2.3.2, it would be difficult to detect impacts from these upstream municipal wastewater sources given the dilution factor and mixing that would occur between the effluent discharge locations and the Churchill River at HV-GB. There are also considerable distances between the upstream discharges and the study area that would allow for the natural decaying factor of many pathogenic bacteria and viruses that may be elevated due to wastewater releases.

There are also several industrial inputs of wastewater to the Churchill River in the upstream reaches. Table 3 summarizes the industries in the National Pollutant Release Inventory (NPRI) for 2007 located within the Churchill River basin including those reporting releases to water. The characteristics of these releases (e.g. metal mine effluents) would likely differ from what is generated as municipal wastewater and therefore they have not been investigated further at the study site.

Table 3 - Current NPRI Locations Within the Churchill River Basin

Industry Name	Reported Substances Released to Water	2007 Reported Releases to Water (tonnes)
Wabush Mines – Scully Mines	Manganese (and its compounds)	18.257
Iron Ore Company of Canada – Carol Project	Chromium (and its compounds) Zinc (and its compounds)	0.53 14.994
Town of Wabush –Incinerator	None reported	N/A
5 Wing Goose Bay	None reported	N/A
Shell Canada Products – Labrador City Terminal	None reported	N/A

Source: EC, 2007

1.2.5 Happy Valley-Goose Bay Wastewater Services

Sewage from 5 Wing Goose Bay, the north side of Goose Bay, Spruce Park and Hamilton Heights are collected at different locations and are eventually conveyed to a 300 mm (12”) diameter concrete trunk sewer that carries the untreated sewage to the Birch Island outfall (photo 2). The Birch Island outfall discharges untreated municipal sewage to the southern shore of the Churchill River (Town of HV-GB, 2009). Sewage from the remaining areas is collected at different locations and is eventually discharged untreated by way of a 600 mm (24”) diameter corrugated metal pipe in proximity to the intersection of Corte Real Road and Hamilton River Road (photo 3).

Photo 2 - Birch Island Outfall

This outfall is commonly referred to as the Lower Outfall. The approximate locations of the outfalls are indicated on Figure 3.

There are fourteen active lift stations to convey sewage to the two main outfalls. The lift stations are checked daily by town staff. Stations are outfitted with flashing red indicator lights and the public is directed to contact the town if the alert is activated (Town of HV-GB, 2009).

Photo 3 - Lower Outfall (Corte Real Rd)

A field program was carried out for the town in 2005 from April to November to characterize the quality and volume of wastewater from the two outfalls (BAE Newplan Group Limited, 2006). Results from the 2005 study are summarized in Table 4.

Table 4 – Wastewater Characterization – 2005 Field Program (April – November)

Parameter	Units	Birch Island Outfall	Lower Outfall (Corte Real Rd)
Average Flow	m^3/day	136.8	100.8
Peak Flow	m^3/day	986.4	216
Fecal Coliforms	MPN/100ml	937,500	760,000
Biochemical Oxygen Demand (BOD)	mg/L	58	160
Total Suspended Solids (TSS)	mg/L	80	100
Ammonia	mg/L	11	13
Phosphates	mg/L	1.1	1.6

Notes: m^3/day – cubic metres per day; MPN/100ml – most probable number per 100 milllilitres; mg/L – milligrams per litre; Source : BAE Newplan Group Limited, 2006

The results indicate that the Lower Outfall has a more concentrated effluent with slightly higher concentrations of measured parameters. However, the Lower Outfall has a lower average flow, and a substantially lower peak flow than the Birch Island Outfall. Total average combined flow for the two outfalls is approximately 238 m^3/day or 0.0028 m^3/sec. Given that the Churchill River has an average mean daily discharge of 1740 m^3/sec, a dilution factor of approximately 1:620,000 for effluent to receiving water is estimated for the combined outfalls. This dilution factor assumes the effluent is completely mixed with the river water. However, this does not readily occur in larger river systems where effluent plumes have been detected several kilometres downstream due to ineffective mixing in natural river systems. A previous study by the Newfoundland and Labrador provincial government indicated that mixing did not occur readily at the two outfalls in HV-GB (NDEL, 1989).

The conceptual design for a wastewater treatment system has been developed by a consultant for the Town of HV-GB. A presentation was made by BAE Newplan Group Limited to the Town in 2006 outlining a basic system design. The design included two forced mains connecting to a treatment plant and a lagoon system prior to discharge to the Churchill River. Complete funding for this treatment plant was not secured at the time of this study.

1.2.6 Local Water Uses

The primary uses of surface water from the Churchill River near HV-GB are for supporting aquatic life, for recreational use (boating, swimming, etc.), and for limited agricultural use. Drinking water for the town is obtained from a groundwater source (wellfield) and from surface water taken from Spring Gulch Brook. The well field is in proximity to the river and likely receives recharge from the river. It is not known if any local people use water from the Churchill River for drinking water purposes. Drinking water use was not considered for this study as the town well field and Spring Gulch Brook are upstream of the two wastewater outfalls. Potential for agricultural water use was considered but the limited agricultural activity in the area did not warrant further investigation.

1.2.7 Applicable Guidelines

The province of Newfoundland and Labrador has adopted the Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines for water, sediment and biota. The following guidelines have been used in this assessment:

- *Recreational Water Quality Guidelines and Aesthetics* (CCME, 2004)
- *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life* (CCME, 2002a)
- *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (CCME, 2002b)
- *Canadian Tissue Residue Guidelines for the Protection of Wildlife Consumers of Aquatic Biota* (CCME, 2001)

Many parameters do not have established CCME guidelines either because they have not been derived or the parameter is not necessarily a risk to the intended use. In addition the following guideline was used for comparison purposes for mercury in biota:

- *Canadian Standards ("Maximum Limits") for Various Chemical Contaminants in Foods* (HC, 2007)

2 Methodology

2.1 Sample Locations

Sample locations were selected in order to assess water and sediment quality impacts from the wastewater outfalls. Locations for the collection of biota samples (i.e. fish) were selected based on the expected impacted area (from wastewater discharge) where fish were likely to be present and, at background locations, based on where similar habitat and species were likely to be present. Sample locations for bacteria sampling were selected to provide spatial coverage and to assess the concentrations of fecal coliforms in the main recreational water use areas (i.e. Happy Valley Marina and the boat launch area for travel to Mud Lake). The bacteria sampling locations were in proximity to water and sediment locations and are discussed further in Section 3.1.4.

Sample locations for water, sediment, and biota are presented in Figure 3. Sample location co-ordinates were obtained using a Garmin® Rhino 530 GPS unit. The following Table 5 identifies the sample locations and the rationale behind the selection of the sample locations.

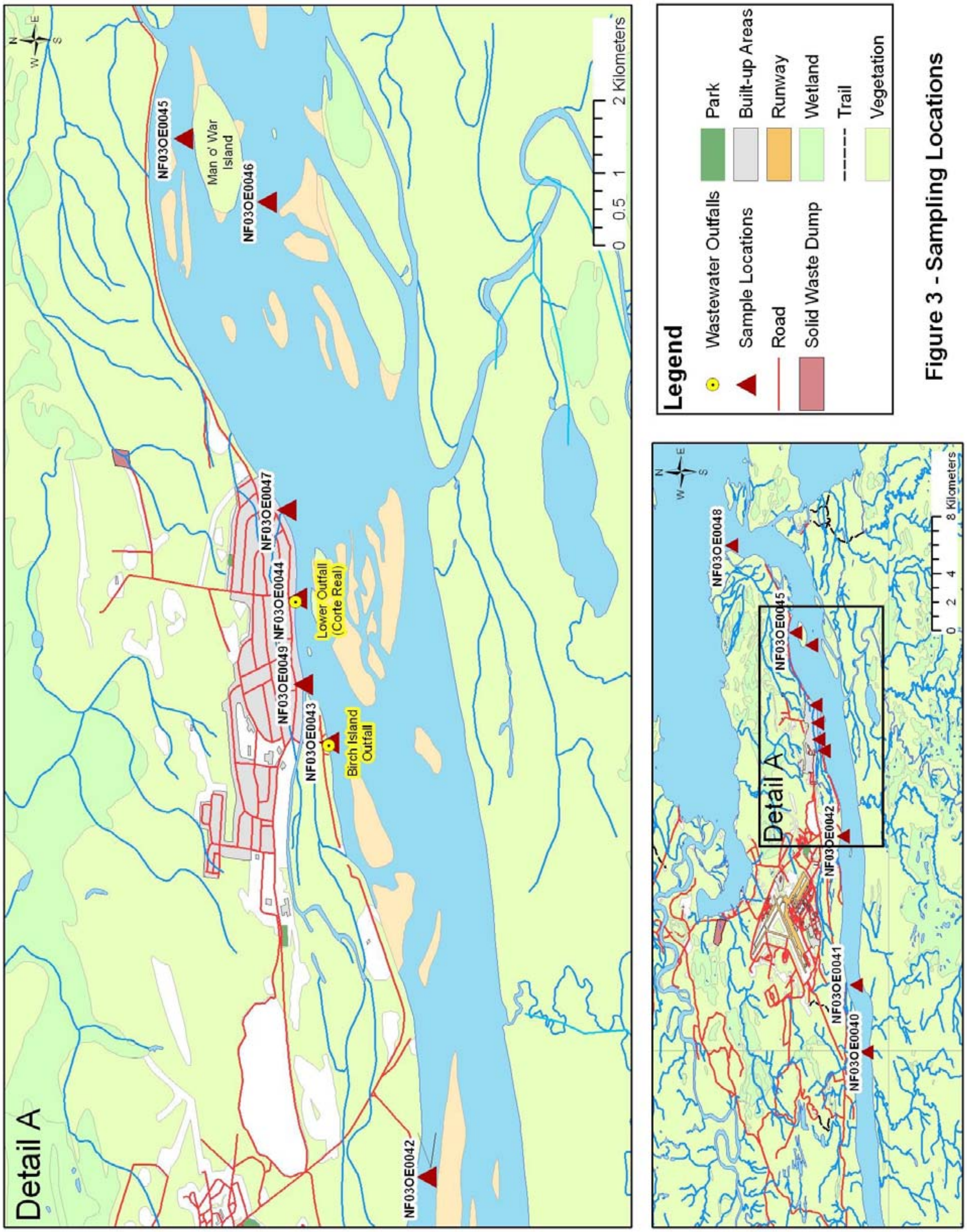


Figure 3 - Sampling Locations

Table 5 - Sample Locations and Rationale

Sample Location ID	Latitude	Longitude	Location Description	Rationale for Sample Location
NF03OE0040	53.26416	-60.50089	Downstream of Muskrat Falls and upstream of Trans-Lab Hwy Bridge	Upstream of the new bridge to assess background water quality
NF03OE0041	53.27090	-60.45834	Upstream of Town Well Field	Upstream of the well field to assess impact of bridge on water/sediment quality, if any
NF03OE0042	53.27901	-60.36426	Upstream End of Birch Island	In the vicinity of 5 Wing Goose Bay to assess potential impacts from the base before influence on water quality from the outfalls
NF03OE0043	53.29107	-60.31040	Birch Island Outfall	Within anticipated wastewater plume to characterize water/sediment quality near the point source
NF03OE0049 (GILL2)	53.29431	-60.30318	Between Birch Island Outfall and Lower Outfall	Downstream of Birch Island Outfall to assess wastewater impacts to biota
NF03OE0044	53.29499	-60.29257	Lower Outfall (Corte Real Road)	Within anticipated wastewater plume to characterize water/sediment quality near the source
NF03OE0047	53.29638	-60.28160	At Happy Valley Marina	At the main recreational boat launch to assess sediment/water quality downstream of two outfalls
NF03OE0046	53.29875	-60.24339	South of Man o' War Island	Downstream of outfalls in other main channel on south side of island to assess downstream impacts
NF03OE0045	53.30916	-60.23557	North of Man o' War Island	Downstream of outfalls and in main channel north of island to assess downstream impacts
NF03OE0048	53.34965	-60.18065	Downstream of Mud Lake	At the mouth of the Churchill River before emptying into Goose Bay at the head of Lake Melville to assess downstream impacts

In recognition of other potential impacts to water and sediment quality in the Churchill River, primarily from the contamination documented at 5 Wing Goose Bay, an attempt was made to separate these impacts by locating a sample location (NF03OE0042) in proximity and slightly downstream of 5 Wing Goose Bay. However, it is acknowledged that it would be extremely difficult to identify the actual source of all contaminants encountered without further detailed study.

2.2 Sampling Procedures

Water, sediment and biota sampling was completed using procedures outlined in the following two manuals:

- *Canada-Newfoundland and Labrador Water Quality Monitoring Agreement Sampling Manual (Water, Sediment and Biological Sampling),* (NL DOEC, 1999); and,
- *Sampling for Water Quality* (EC, 1983)

A brief discussion of the specific procedures and equipment used is included in the following sections.

2.2.1 Water Sampling

Grab samples were collected at a depth of 0.3 metres below the surface from the side of the boat. Lab-supplied bottles were pre-labelled and immersed in the water to collect the sample. Sample date and time were recorded on the bottle. The boat was anchored upstream and the water sample was taken from the bow of the boat to prevent contamination from the boat and motor. Samples were immediately placed in coolers on ice.

Photo 4 - Multi-parameter Meter with GPS

Field measurements were taken using a recently calibrated multiparameter YSI® 600 OMS sonde connected to a Garmin Rino® 530 GPS unit. The sensors on the sonde were situated at a depth of 0.3 m at the front side of the boat to minimize influence from the boat and motor. This set-up was capable of logging in-situ temperature, dissolved oxygen, specific conductance and pH while simultaneously obtaining the co-ordinates at each measurement location. This set-up enabled logging of field parameters at 5 second intervals while the boat was moving. The logged data was plotted on a map to assess spatial variability in the parameters. A photo of the set-up is shown in Photo 4 – Multi-parameter Meter with GPS. Data obtained from this set-up is referred to as cruise data and is discussed in Section 3.1.2.

Bacteria sampling was completed by submerging the bottle to a depth of 0.3 metres. Bottles were not rinsed as they contained a fixer for neutralizing chlorine in chlorinated waters (i.e. treated water). Samples were immediately placed in a cooler with ice and transferred to a refrigerator with a temperature below four degrees Celsius. Due to the limited holding time of bacteria samples of 30 hours, samples were collected as close to the departure time for air shipment to the Public Health Laboratory in St. John's. Instructions were given to the courier to keep the cooler in a refrigerated area during overnight storage. Even with best efforts to co-ordinate this, the samples did not arrive at the laboratory within 30 hours of sampling.

2.2.2 Sediment Sampling

Sediment samples were taken using an Ekman dredge deployed from the side of the boat. Depth of the sample was obtained using a Humminbird® Depth sounder and recorded in a field book. Due to the sandy, unconsolidated nature of the sediments, it was not necessary to prepare the sample on a tray. Instead, the top layer of sand was placed in a lab-supplied container using a new, clean pair of nitrile gloves. The sediment samples were placed inside a cooler with ice until arrival at the field warehouse where they were frozen until ready to ship to the laboratory using an overnight carrier. The Ekman dredge was rinsed in the Churchill River several times in between each sampling location to minimize carry-over of sediments from previous sampling sites. The nature of the sediments described above was such that carry-over was not a major issue because the sediments did not stick to the dredge.

2.2.3 Biota Sampling

Prior to collection of fish samples, an application was made to the regional Department of Fisheries and Oceans (DFO) to obtain an Experimental License to conduct experimental work. Fish sampled under this study were collected under DFO Experimental License NL-605-08.

Photo 5 - Gill Net

Fish were collected using a 9 x 1.5 metres gill net with a 62 millimetre opening. The gill net was deployed at three different locations for varying amounts of time. A photo of the net used is shown in Photo 5. Flow velocities in the Churchill River made it difficult to deploy the net in the main channels. Deployments were limited to shallow areas (<3 metres) with lower flow velocities.

Fish obtained using the gill net were immediately double wrapped in aluminum foil and individually placed inside acid-rinsed ziploc bags. Samples were placed inside a cooler with ice until arrival at the field warehouse within two hours where they were frozen until ready to ship to the laboratory using an overnight carrier.

2.3 Laboratory Analysis

Due to the remoteness of the study area, samples were shipped by air to the various laboratories for analysis. Inorganic analyses were conducted by Environment Canada's Atlantic Laboratory for Environmental Testing (ALET) in Moncton, New Brunswick. Organic analyses were conducted by Environment Canada's National Laboratory for Environmental Testing (NLET) in Burlington, Ontario. Bacteriology samples were analysed by the Newfoundland and Labrador Public Health Laboratory in St. John's, NL. All three laboratories are accredited by the Canadian Association for Laboratory Accreditation (CALA) which assures that the data are produced according to the highest standards of quality (www.cala.ca).

Samples were analysed for compounds that are typically found in receiving environments in order to provide an indicator of wastewater impacts in the study area. Parameters that are routinely monitored in wastewater treatment plant effluents such as carbonaceous biochemical oxygen demand ($CBOD_5$) and total residual chlorine (TRC) were not examined since it was determined that they would not be good indicators. TRC would not be present in the receiving environment since there is no chlorination of the wastewater prior to discharge and the inherent variability of $CBOD_5$ would not make it a good indicator in the aquatic environment. Table 6 provides a summary of the analyses completed as part of this study.

Table 6 - Sample Analyses Summary

Sample Matrix	Number of Samples	Sample Analyses Conducted
Water - inorganic and organic	12	• Major Ions • Nutrients • Physicals • Metals (including Mercury) • Polycyclic Aromatic Hydrocarbons (PAHs)

Sample Matrix	Number of Samples	Sample Analyses Conducted
Water – bacteriology	17	• Fecal coliforms (*Escherichia coli*)
Sediment	10	• Metals (including Mercury) • PAHs • Polychlorinated Biphenyls (PCBs) • Organo-chlorine (OC) Pesticides
Biota	4	• Metals (including Mercury) • PAHs • PCBs • OC Pesticides

2.4 Quality Assurance and Quality Control (QA/QC)

Quality assurance and quality control (QA/QC) samples were collected to assess the bias and representativeness of the samples collected during this study. In this study, three types of quality control samples were collected: field blank, rinsate blank, and duplicate samples. The data was also screened for outliers and anomalous results using basic data validation techniques (e.g. ion balances, etc.).

Detailed information for each type of QA/QC sample is provided below and a discussion of the QA/QC sample results is included in Section 3. Overall, the QA/QC samples and data validation indicated that the study results were of good quality.

2.4.1 Field Blank

A field blank is used to assess if any contamination was introduced during the sample collection, sample transportation, and sample analysis processes. A field blank was prepared on August 22, 2008 using laboratory supplied distilled water. The field blank was prepared while in the boat using the same procedure and equipment as the regular water quality samples. The laboratory supplied water was poured into the water quality sample bottles, labelled with the date and time, and kept with the other samples until reception at the laboratory.

2.4.2 Rinsate Blank

A rinsate blank was used to assess the efficiency of the Ekman dredge cleaning procedure between sediment sampling locations. A rinsate blank was prepared on August 22, 2008 using laboratory supplied distilled water. After cleaning the sediment sampling dredge by rinsing it in the Churchill River water several times, laboratory supplied distilled water was poured in the Ekman dredge and collected in the water quality sample bottles, labeled with the date and time of collection, and kept with the other samples until reception at the laboratory.

2.4.3 Duplicate Samples

Duplicate samples are used to assess the variability introduced during the sample collection and analysis processes. In this study, a duplicate sample was collected on August 22, 2008 at station NF03OE0043 for both the water and sediment matrices.

3 Results

3.0 Study Period Details

Sampling was conducted over a four day study period from August 21 to 24, 2008. No local activities (e.g. earthworks or in-stream work) that could have a major influence on water quality were observed along the shores from the Trans-Labrador Highway Bridge downstream to Goose Bay at the head of Lake Melville. Some recreational boaters were observed on the river from the Happy Valley marina area to the entrance of Goose Bay at the head of Lake Melville. Boats were observed transporting people to the community of Mud Lake on all four days.

Discharge calculated at the Muskrat Falls hydrometric station was approximately 1325 m^3/sec for the duration of the study period (WSC, 2008). There were no precipitation events (> 0.5 millimetres) recorded at the Goose Bay climate station during the study period (EC, 2009). There were two precipitation events directly prior to the study period recorded at the Goose Bay climate station on August 19, 2008 (28.4 mm) and August 20, 2008 (6.4 mm).

All results are based on a one-week sampling period and don’t take into account seasonal flow variations and weather changes. This period was selected as flows would be expected to be minimal (i.e. low flow period) and the dilution effect on chemical parameters of increased precipitation would be minimized.

3.1 Water Sampling Results

Water samples were collected on August 21 and 22, 2008 for analysis of inorganic and organic parameters. Field parameters were collected on August

21 and 22, 2008 using the multi-parameter meter and GPS set-up. Continuous field data (i.e. field meter readings and corresponding coordinates) collected while the boat was moving is referred to as cruise data. Water samples for fecal coliform (*E. coli*) analysis were collected within a four hour period on August 24, 2008. A discussion of the sample results for water is included in the next five sub-sections.

3.1.1 Water QA/QC Samples

The analytical results from the field blank sample (Tables A.1, A.2, A.3, and A.4, Appendix A) show that the detections in these samples were extremely low, indicating that the collection, shipping, and analysis did not introduce appreciable levels of contamination in the samples from this study.

For the duplicate sample, the highest relative percent difference (RPD) between the primary and the duplicate water sample result was 15% for the low level mercury analysis. These results are reported at low detection levels relative to other metals in nanograms per litre (parts per trillion). All other compounds detected in both the primary and the duplicate sample had RPDs below 10% showing good sampling and analytical methodology.

3.1.2 General Chemistry and Nutrients

The results of the general chemistry analyses are included in Table A.1, Appendix A. In general, concentrations were within the ranges observed in the upstream Muskrat Falls historical data (Table 1) for most parameters. Concentrations of major ions and nutrients showed little change from upstream to downstream sections. All parameters were within applicable CCME guidelines for the protection of aquatic life in a freshwater environment.

Two potential indicators of influence from the two outfalls were identified within the general chemistry dataset. The first was an increase in specific conductance and temperature in the vicinity of the outfalls and in areas directly downstream of the outfalls. Secondly, an increase in sodium and chloride, two major ions, was detected near the outfalls and in areas downstream.

Specific conductivity was found to be higher around the two outfalls and in downstream sections than in the upstream sections where the conductivities were quite stable at 21-22 microSiemens/centimetre (µS/cm) as illustrated in Figure 4 – Cruise Data – Specific Conductance. Specific conductance also appeared to be slightly higher in the shallower, near bank areas downstream of the outfalls as compared to the deeper channel where the majority of flow was concentrated. Higher conductivities (>24 µS/cm) were encountered at greater distances (up to 400 metres) downstream of the Birch Island Outfall than at the Lower Outfall where conductivities quickly returned close to background levels encountered in upstream sections. This indicated that there was better mixing at the Lower Outfall where the channel was narrower, deeper and flow velocities were greater than near the Birch Island Outfall.

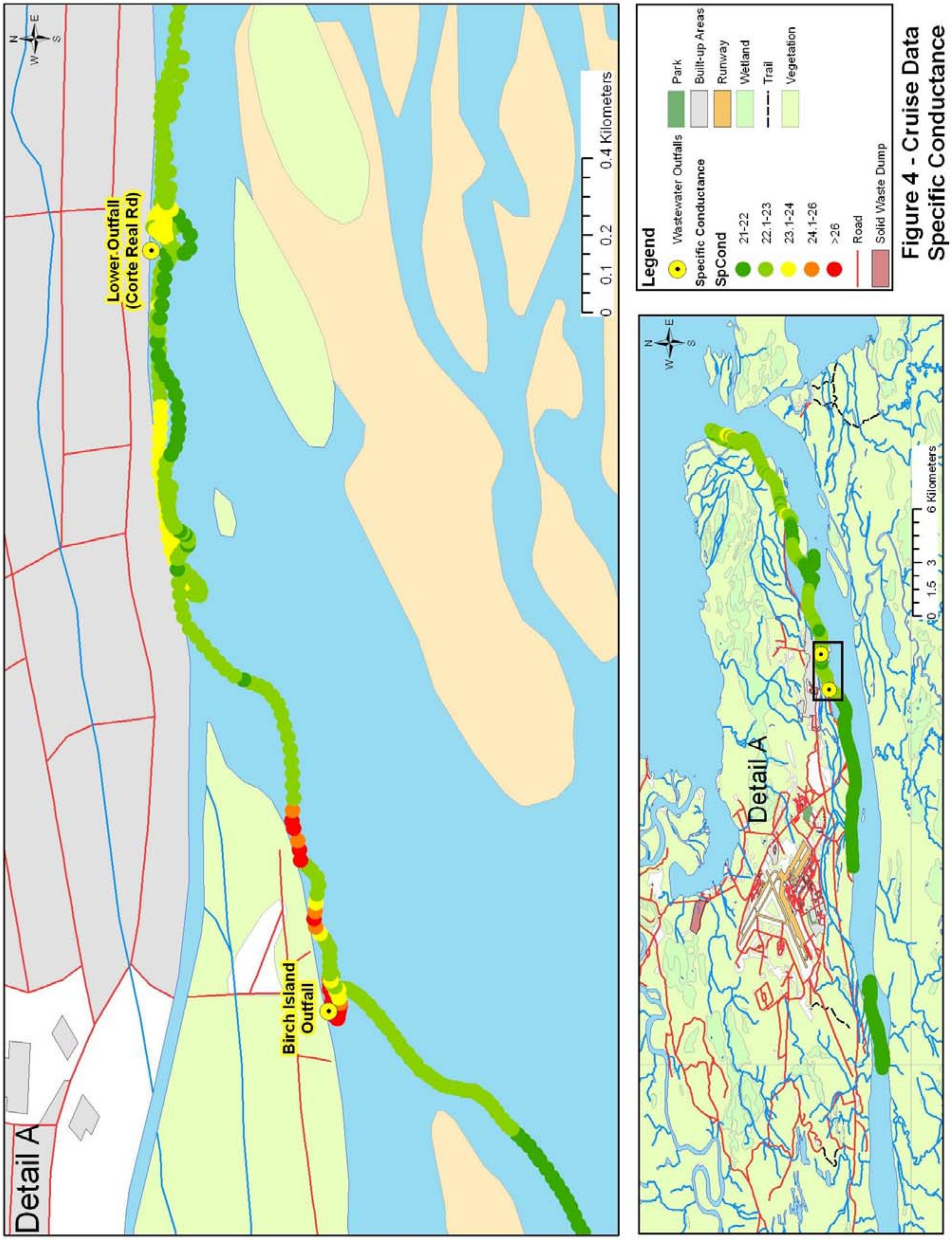


Figure 4 - Cruise Data
Specific Conductance

The other parameters, logged at the same time as specific conductance, were also analyzed for spatial patterns. Temperature showed a similar pattern to specific conductance indicating the effluent was a higher temperature than the receiving water on that particular day. Specific conductance was a better indicator because it showed less variability in upstream sections than temperature did. The remaining parameters, pH and dissolved oxygen, showed less variability and therefore were not useful indicators. It was not possible to map the complete plume due to the size and extent of the river and also the time constraints. However, the cruise data did indicate some of the plume dynamics in the vicinity of the outfalls.

Two of the major ions, sodium and chloride showed slight increases in concentrations around the two outfalls and in downstream sections. The ratio of major ions (cations or anions) is often evaluated to remove the effect of discharge over time or dilution in order to evaluate inputs of water with different chemistries. Sodium and potassium are usually grouped due to low natural concentrations of potassium relative to the other major cations. A change in the ratios could indicate that water with a different chemical composition is influencing the water quality. The major cation ratios at sampling sites going from upstream to downstream are presented in Figure 5.

Figure 5 – Major Ion Ratios - Cations

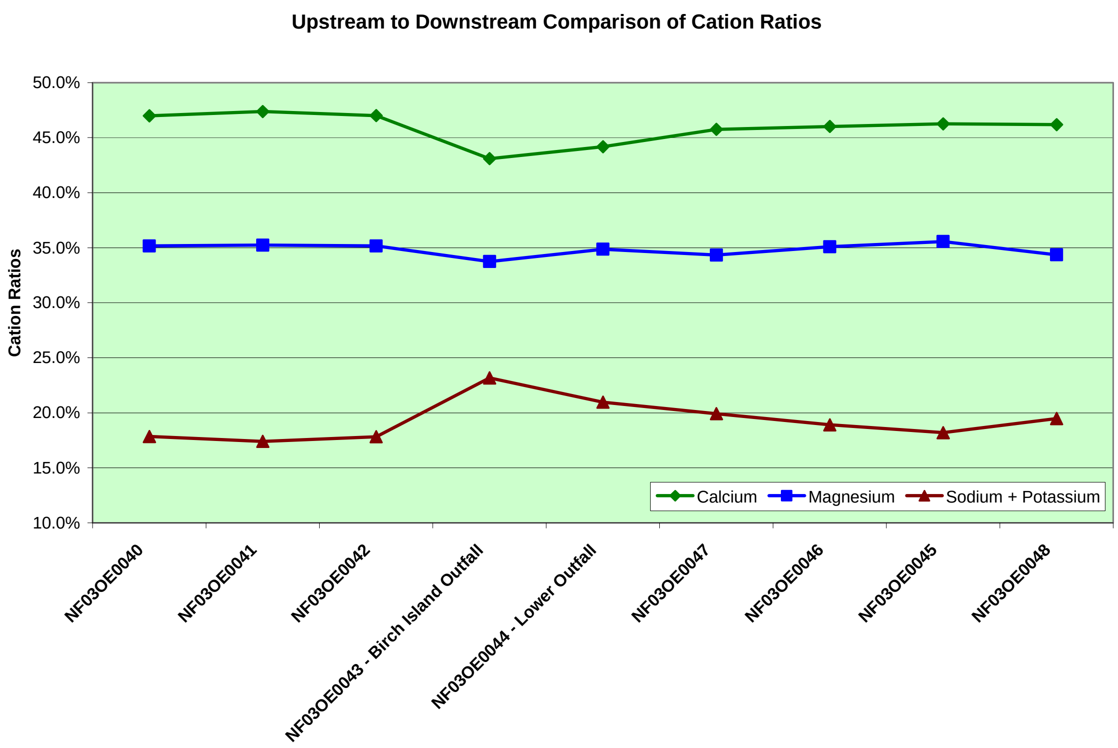


Figure 5 clearly shows the change in cation ratios that occurs near the Birch Island Outfall (NF03OE0043), and does not return to upstream conditions until sample location NF03OE0045. This indicates the influence of water with a different chemical composition dominated by sodium. The anions show a similar trend with chloride showing the greatest increase in percentage. This would indicate a sodium chloride type water influencing the calcium bicarbonate type water found in the Churchill River at these stations. Ratios return to upstream (NF03OE0040) conditions by sample location NF03OE0045.

There is also a change in cation ratios visible at the sample location NF03OE0048 where the saltwater influence of downstream Lake Melville could start to influence ratios. A vertical profile of water quality field parameters at the location NF03OE0048 showed no change in parameters with depth indicating that the freshwater-saltwater interface was still some distance downstream during the sampling period.

Nutrient concentrations were within the ranges measured over a ten year period at the Muskrat Falls monitoring location. Total phosphorus (TP) concentrations (0.022 to 0.032 mg/L) measured in August 2008 were higher than the median TP concentration of 0.015 mg/L (1997-2007) measured at Muskrat Falls. It is suspected that the elevated TP in August was due to the combination of low flow conditions and suspended organic material. Total nitrogen concentrations reflected the median concentration at Muskrat Falls. There was no discernible variability in nutrient concentrations in relation to the outfalls and therefore nutrients could not be used as an indicator at this location.

3.1.3 Metals

The results of the metals analyses are included in Table A.2, Appendix A. The CCME guidelines were exceeded for aluminum and iron for all samples collected. All other parameters were within the applicable CCME guidelines for the protection of aquatic life in a freshwater environment.

Aluminum and iron concentrations are likely elevated due to a combination of the analytical procedure (e.g. extractable metals analysis that involves a weak acid digestion and therefore can be influenced by suspended sediment) and naturally occurring sources of aluminum and iron such as aluminosilicate clays or iron sulfide minerals that are suspended in the water column and are the result of natural weathering processes. There is a marked decrease in the clarity of the Churchill River downstream of Muskrat Falls due to increased suspended sediment and this is the likely source of the elevated aluminum and iron concentrations. High levels of aluminum and iron have been recorded at the Upper Muskrat Station over the past thirty years with average aluminum and iron concentrations at this station exceeding CCME Guidelines (Envirodat, 2009).

Metals concentrations showed little variability between stations. A slightly higher mercury concentration of 4.4 nanograms per litre (ng/L) relative to other samples was observed at NF03OE0042. Mercury concentrations in the remaining samples ranged from 1.2 to 2.6 ng/L. All mercury concentrations were below the CCME guideline of 26 ng/L for the protection of aquatic life.

3.1.4 Bacteria

Samples for fecal coliforms (indicator of *E. coli*) were collected on August 24, 2008 at 15 locations along the Churchill River. Sample locations for fecal coliforms were generally at the same locations as the general water quality sampling locations with additional samples taken at other locations to assess the spatial distribution of fecal coliforms. Sample locations and fecal coliform concentrations are shown on Figure 6 – Bacteria Sampling Locations and Results. Individual sample results are summarized in Table A.3, Appendix A.

There was a delay in getting the samples to the laboratory within the 30 hours suggested between sampling and analysis due to the availability of flights between HV-GB and St. John's where the laboratory is located. The maximum time from sampling to sample preparation at the laboratory was 44 hours for the samples collected on August 24, 2008. Die-off of the bacteria may have occurred prior to analysis because of the extended holding time. This could bias the concentrations lower than actual concentrations as some colonies may not have survived. Therefore, this was considered when interpreting the results and applying the guidelines.

The highest concentration of fecal coliforms was detected in the area downstream of the Birch Island Outfall at B13 in the vicinity of NF03OE0049. The concentration at this location was 30,000 colony forming units per 100 millilitres (cfu/100ml). This is also the location of the gill net where biota samples were collected. The water in this area appeared to have lower velocities in comparison to the main channel of the river to the south. Water depth at the sampling location was approximately 1.8 metres. There was also increased staining of the shoreline rocks and vegetation with a light colored residue in this area relative to sections upstream. Photo 6 shows the degree of residue on the vegetation at B13 downstream of the Birch Island Outfall while Photo 7 shows the vegetation at B1 on the southern shore with no residue visible.

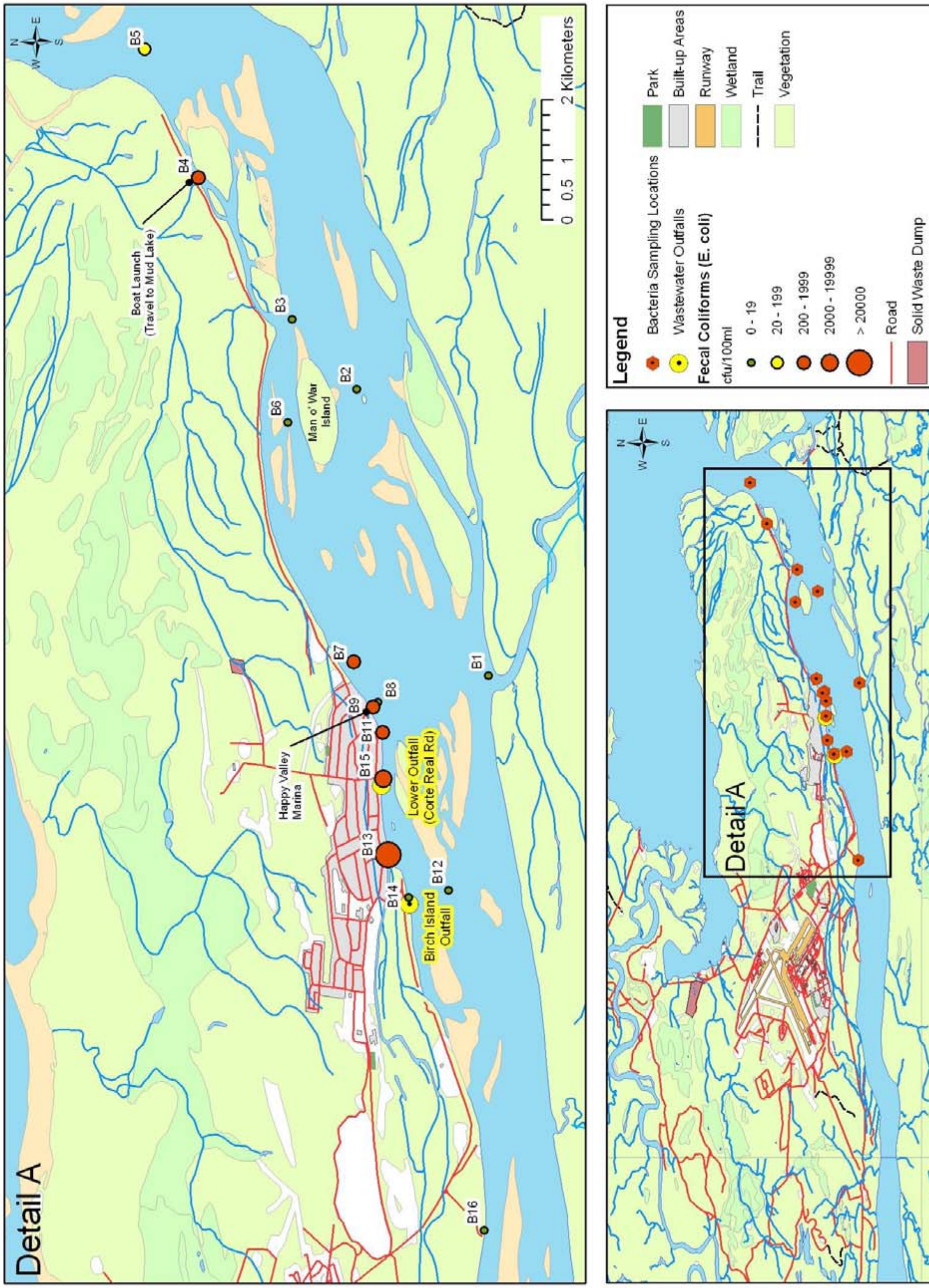


Figure 6 - Bacteria Sampling Locations and Results

Photo 6 – Residue on Vegetation near B13 Downstream of Birch Island Outfall

Photo 7 – Vegetation near B1 on Southern Banks of Churchill River

Elevated concentrations of fecal coliforms, greater than the CCME recreational water quality guideline (CCME, 2004) of 200 cfu/100ml, were also encountered at B15 – near the Lower Outfall (2000 cfu/100ml), at B9 – near the Happy Valley marina (duplicate sample average was 800 cfu/100ml), and also at B11 between the Lower Outfall and the Happy Valley marina (1000 cfu/100ml). The sample (14 cfu/100ml) taken at B8 approximately 100 metres south of the HV marina shoreline illustrates how the higher concentrations are found along the shoreline (B9) where the depth is shallower and velocities are slower. Samples in the main deep channel (B2, B3, B6, B8, and B12) and the sample location (B16) upstream of the outfalls had the lowest concentrations.

The sample taken at the Birch Island Outfall (B14) had low concentrations of fecal coliforms (10 cfu/100ml) relative to the sample taken approximately 750 metres downstream at B13 (30,000 cfu/100ml). This could be attributed to the sample being taken at a depth of 0.3 metres below the surface. The sampling location was close to the outfall and therefore it is suspected that the wastewater had not yet reached the surface from its submerged discharge point. Specific conductance cruise data in the vicinity of the outfall did indicate significant chemical influence from the outfall at the bacteria sampling location B13.

It should be noted that the CCME recreational water use guideline is applied using the geometric mean of 5 samples collected in no more than a 30 day period (CCME, 2004). Since this was a one-time sampling event, an application of the guideline is not necessarily appropriate, however, it does give an indication of areas where exceedances may occur. Sampling by the province conducted from 1981 to 1988 at similar locations confirmed concentrations in the same ranges as obtained in August of 2008 (NDEL, 1989).

An elevated concentration of fecal coliforms (200 cfu/100ml) was detected at B4 which is at the boat launch commonly used for travelling to the Mud Lake community. It is unclear whether the source of this elevated level is from the upper outfalls and is a remnant of the plume that is remaining close to the northern shore or if there are local sources such as straight pipes or malfunctioning septic systems in the vicinity of the sampling area. Concentrations above background levels were also detected in the furthest downstream station at B5 (26 cfu/100ml) also indicating some residual impacts from wastewater inputs.

3.1.5 Organics

3.1.5.1 Polycyclic Aromatic Hydrocarbons (PAHs)

Results of the polycyclic aromatic hydrocarbon (PAH) analysis for the water samples are included in Table A.4, Appendix A. PAHs were not detected above the laboratory detection limit in any of the water samples collected.

3.2 Sediment Sampling Results

Sediment samples were collected on August 21 and 22, 2008 for analysis of inorganic and organic parameters. A discussion of the sample results for sediment is included in the next three sub-sections.

3.2.1 Sediment QA/QC Samples

As shown in Table A.2, Appendix A, the rinsate blank had a few measurable amount of metals. However, the concentrations measured in the rinsate blank are in micrograms per litre (µg/L) or parts per billion (ppb) whereas the sediment samples are reported in milligrams per kilogram (mg/kg) or parts per million (ppm). The low concentrations of metals in the rinsate blank are too low to have had any effect on the sediment sample results which indicates that the cleaning procedure was sufficient.

The highest relative percent difference (RPD) between the primary and the duplicate sediment sample (Station ID: NF03OE0043) was 61% for cadmium. Because of this high variability, cadmium results should be carefully considered when evaluating the results for each sampling site. The other metals had RPDs below 10% showing good sampling and analytical methodology.

3.2.2 Metals

Results of the metals analysis for the sediment samples are included in Table B.1, Appendix B. Concentrations of metals in the sediments were below the applicable CCME Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME, 2002a).

There was no distinct spatial pattern detected in the metals results. Sediments with higher concentrations of metals are likely due to sediment grain size as the relative ratio of different metals remained the same with all sediment samples analyzed. No grain size analysis was completed to confirm this but local studies by Nalcor Energy suggest that sediments with more fine grained material have higher concentrations of metals but in similar ratios to each other. Concentrations were within the ranges observed by Nalcor Energy in their sediment quality studies conducted in 1998 and 2006 (Nalcor Energy, 2009).

3.2.3 Organics

3.2.3.1 Polycyclic Aromatic Hydrocarbons (PAHs)

Results of the polycyclic aromatic hydrocarbon (PAH) analysis for the sediment samples are included in Table B.2, Appendix B. PAHs were not detected above the laboratory detection limit in any of the sediment samples collected.

3.2.3.2 Polychlorinated Biphenyls (PCBs)

Results of the polychlorinated biphenyls (PCBs) analysis for the sediment samples are included in Table B.3, Appendix B. Total PCBs were detected at low concentrations ranging from 2.45 to 7.77 micrograms per kilogram (µg/kg). Concentrations of Total PCBs in the sediments were below the applicable CCME Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME, 2002a).

Concentrations did not vary considerably across the study area or in relation to the wastewater outfalls. The highest concentration (7.77 µg/kg) was detected at NF03OE0041 which is upstream of 5 Wing Goose Bay. A source of these PCBs was not determined but it is unlikely they are related to municipal wastewater inputs from HV-GB.

3.2.3.3 OC Pesticides

Results of the organochlorine (OC) pesticides analysis for the sediment samples are included in Table B.4, Appendix B. OC pesticides were not detected above the laboratory detection limit in any of the sediment samples collected.

3.3 Biota Sampling Results

In order to assess aquatic health, an attempt was made to collect and analyze fish tissue in the vicinity of the outfalls and also in a suitable reference condition (i.e. upstream reach or tributary). Due to the short study period and the limited fish habitat in the general study area (i.e. high flow, sandy bottom in the main channel of the Churchill River), it was not possible to collect many fish to analyze.

A total of four fish were collected on August 23, 2008 using a gill net set out approximately one kilometre downstream from the Birch Island Outfall at location NF03OE0049. There were visible signs of municipal wastewater impacts at the sampling location including solids and floatables. The species of fish caught were white suckers (*Catostomus commersonii*), a common fish species in the Churchill River as reported by Andersen, 1985. All results are from individual whole fish samples that were laboratory homogenized.

Fish samples were all similar in size and had a median fork length of 25.5 cm (range 25-28 cm) and a median weight of 190 g (range 170-210 g). Based on growth charts for white suckers in the Churchill River generated by Andersen, 1985, the fish were estimated to be in the five to nine year range. Fish appeared to be healthy with the exception of one fish which had a small growth (papilloma) on the side of its head. Increased prevalence of these papillomas have been correlated to PCBs and OC pesticides in fish tissue by Premdas et al, 1995. However, the lack of reference fish samples and the low sample number (i.e. four fish) for this study on the Churchill River make it impossible to make any formal conclusions about the observed papilloma and the concentrations of contaminants observed in the four fish analysed.

3.3.1 Metals

Results of the metals analysis for the biota samples are included in Table C.1, Appendix C. All results are for whole fish and are reported as wet weights.

The form of mercury analyzed was extractable mercury and would therefore include all mercury in methyl mercury form as well as inorganic mercury. The CCME Tissue Residue Guideline (CCME, 2001) of 0.033 milligram per kilogram (mg/kg) is for methyl mercury, however, this guideline is commonly used for comparison purposes for extractable mercury assuming that most of the mercury in fish tissue is methyl mercury (Rodgers, 1994). In addition to the CCME guidelines, Health Canada has established the level of mercury acceptable for fish for commercial sale at 0.5 mg/kg (HC, 2007). While white suckers are neither commonly used for food nor sold commercially, they are prey for larger predatory fish that are commonly consumed in the area. As mercury is known to bio-accumulate through the food chain, higher levels of mercury in prey remain a concern.

Mercury was detected in all four fish and ranged from 0.016 to 0.062 mg/kg with two of the fish containing levels of mercury above the CCME Tissue Residue Guideline of 0.033 mg/kg. None of the fish exceeded the Health Canada guideline.

Copper was detected at concentrations ranging from 28 to 79 mg/kg. Since there were no fish caught in reference areas (i.e. away from possible wastewater sources), it was not possible to determine if these copper concentrations are related to the outfalls or if they are natural levels given the local habitat characteristics. In comparison to copper concentrations in livers of white suckers as reported by Harrison and Klaverkamp, 1990, the concentrations detected in the Churchill River whole fish samples were slightly higher than the means for three groups of lakes located near Flin Flon, Manitoba (Flin Flon group mean – 20.2 mg/kg, Manitoba group mean – 4.3 mg/kg, Saskatchewan group mean – 10.2 mg/kg).

3.3.2 Organics

3.3.2.1 Polycyclic Aromatic Hydrocarbons (PAHs)

Results of the polycyclic aromatic hydrocarbon (PAH) analysis for the biota samples are included in Table C.2, Appendix C. PAHs were not detected above the laboratory detection limit in any of the biota samples collected.

3.3.2.2 Polychlorinated Biphenyls (PCBs)

Results of the polychlorinated biphenyls (PCBs) analysis for the biota samples are included in Table C.3, Appendix C. PCBs were detected in all four whole fish samples. Concentrations of total PCBs ranged from 21.6 to 80.2 nanograms/gram (ng/g) with a mean concentration of 49.5 ng/g (wet weight).

Concentrations of PCBs in whole fish samples were within the ranges that were observed in Southern Labrador Lakes (Lockerbie and Clair, 1988), in particular St. Augustin Lake, where the range of total PCBs concentration in liver tissue was less than the detection limit (unknown) up to 190 ng/g with a mean of 65 ng/g. Approximately 45% of the fish within this group from St. Augustin Lake were white suckers.

An attempt was made to compare the results to the CCME Tissue Residue Guideline, however, the laboratory methodology did not allow the guideline to be accurately applied. The application of the guideline involves the calculation of dioxin toxic equivalents (TEQs) using the sum of toxic equivalent factors (TEFs) for individual PCBs congeners. The laboratory was unable to separate all the congeners required to properly sum the TEFs. As a result, some of the TEFs calculated in Table C.3 included additional congeners and therefore the sum of TEQs was elevated and above the two guidelines for all four samples including the laboratory blank (LAB BLANK).

The small sample size and the lack of reference site samples makes it difficult to determine is any of the PCBs detected in the fish samples are linked to the wastewater outfalls. The source of the PCBs is expected to be atmospheric transport as indicated by Lockerbie and Clair, 1988 in their study of five southern Labrador lakes. Local historical activities such as the reported organics contamination (including PCBs) identified on the Southern Escarpment at CFB

Goose Bay (DND, 2008) may also be a potential source of PCBs in the fish samples. Further investigation would be required to confirm the sources.

3.3.2.3 OC Pesticides

Results of the organochlorine (OC) pesticide analysis for the biota samples are included in Table C.4, Appendix C. Several organic contaminants were detected in the fish samples. The most prevalent contaminant was DDT (dichlorodiphenyltrichloroethane) and its break down products, DDE (dichlorodiphenyldichloroethylene) and DDD (dichlorodiphenyldichloroethane).

Concentrations of DDT (sum of p,p’ and o,p’ isomers) ranged from 0.89 to 14.7 nanograms per gram (ng/g) with a mean of 5.7 ng/g. One sample had DDT concentrations that exceeded the CCME Tissue Residue Guideline of 14 ng/g.

Concentrations of DDT in whole fish samples were within the ranges that were observed in Southern Labrador Lakes (Lockerbie and Clair, 1988), in particular St. Augustin Lake, where the range of DDT concentration in liver tissue was less than the detection limit (unknown) up to 31 ng/g with a mean of 3 ng/g. Approximately 45% of the fish within this group from St. Augustin Lake were white suckers.

The small sample size and the lack of reference site samples makes it difficult to determine is any of the OC pesticides detected in the fish samples are linked to the wastewater outfalls. The source of the OC pesticides detected is expected to be primarily from atmospheric transport as indicated by Lockerbie and Clair, 1988 in their study of five southern Labrador lakes. Local historical activities such as the reported organics contamination (including OC pesticides) identified on the Southern Escarpment at CFB Goose Bay (DND, 2008) may also be a potential source of OC pesticides detected in the fish samples. Further investigation would be required to confirm the sources.

3.4 Key Indicator Parameters for Wastewater Impacts

Parameters that can be used to identify and track impacts from wastewater can be referred to as indicator parameters. Parameters that are commonly used for identifying impacts from wastewater include specific conductance, temperature, total suspended solids (TSS), biochemical oxygen demand (BOD), fecal coliforms, and nutrients (e.g. total phosphorus and nitrogen compounds). All of these were assessed with the exception of BOD that has a holding time of only 24 hours. Of these indicator parameters, only specific conductance, temperature, and fecal coliforms were identified as useful indicator parameters for assessing the impacts of wastewater in the Churchill River in the vicinity of HV-GB.

The cruise data was obtained to assess whether there was any change in the general water quality near the outfalls in relation to the upstream and downstream reaches. This information was then used to assess the zone of mixing and the general area where impacts from the wastewater could be expected. Since the discharge of the river is approximately 650,000 times the discharge from the two combined outfalls, it was expected that the effluent would quickly be diluted by the river water. However, the location of the outfalls and the variability in the river morphology (e.g. braided channels of varying depth and changing flow velocities) was expected to have considerable influence on the mixing zone. The cruise data allowed the continuous assessment of parameters such as specific conductance, pH and temperature over a large area in a short period of time. These were then used as indicators of the zone of impacts. The zone of impact would differ depending on the individual parameters involved. For example, dissolved compounds may quickly be diluted by the volume of water whereas suspended material such as bacteria could persist under the right temperature for quite a distance down the river.

The channel constricted near the Lower Outfall and the channel became deeper (depth at NF03OE0044 was ~10.3 metres) in contrast to the area around the Birch Island Outfall where the channel was wider and shallower (depth at NF03OE0043 was ~1.5 metres). The flow velocity also appeared higher at the Lower Outfall where a large eddy was visible on the downstream side of the outfall (Photo 3). This indicated that the effluent was not being readily mixed with the flowing fresh water in the vicinity of the Birch Island Outfall and at locations between NF03OE0043 and NF03OE0049. This is further supported by the increased conductivity values encountered downstream close to the north shore for up to 500 metres. The presence of a deeper channel with relatively higher flow velocities and the increased specific conductance readings for only 100 metres downstream indicated that the effluent from the Lower Outfall was being more readily mixed with the freshwater than at the upper Birch Island Outfall. The 2005 study (BAE Newplan Group Limited, 2006) also indicated that the Lower Outfall has a lower average flow in comparison to the Birch Island Outfall so this may also contribute to the smaller mixing zone indicated by the specific conductance cruise data.

It was not possible to clearly link any observed impacts in sediment and biota to wastewater discharges from HV-GB. However, impacts to sediment may occur further downstream of the study area (e.g. Lake Melville) where deposition of suspended matter would occur. The lack of fish caught in reference conditions makes it difficult to assess the observed impacts in the fish samples collected downstream of the outfalls.

3.5 Extent of Wastewater Impacts

Using the physical-chemical results (e.g. cruise data) and the bacteriological results (both historical and 2008 data), it was possible to identify two general areas of impacts; an area where wastewater impacts were observed and an area where impacts would likely be expected given the river characteristics at the time of the study. From these areas, two zones of concern (Zone A and Zone B) have been delineated on Figure 7 – Zones of Concern. The following section discusses the two zones and what can be expected in each.

3.5.1 Zone A – Observed Impacts from Wastewater Outfalls

Zone A is primarily located in the area around the upper outfall at Birch Island, the northern shoreline of the Churchill River between the two outfalls, and the downstream section along the northern edge of the river approximately 5 kilometres (km) downstream to Man o' War Island. The extent of Zone A is illustrated on Figure 7, however, as the Churchill River is a dynamic system and the main channel (i.e. deeper channel where major volume of flow is located) changes on a continual basis, the extent of Zone A would need to be re-assessed on a routine basis. Zone A represents a large area (approximately 1.5 km by 10 km) and there is a considerable safety factor built in.

Zone A includes the area where exceedances of the CCME recreational water use guideline have been observed for fecal coliforms. There was also visual evidence of wastewater impacts in this zone including discoloured water, floatables and solids. There was also increased staining (light coloured residue) along shoreline rocks and shrubs in this zone. The highest conductivities were found along the shore in this zone which indicated that the wastewater plume is remaining close to the northern shore and is not mixing readily with the main flow.

Zone A includes one of the major recreational boating area launches in the HV-GB at the Happy Valley Marina (indicated on Figure 7). There are also numerous private boat launches and dock structures within this Zone. There is currently a permanent warning sign posted at the Happy Valley Marina and this can be seen in Photo 8. The sign reads, "CAUTION –WATER

Photo 8 – Warning Sign at Happy Valley Marina (Zone A)

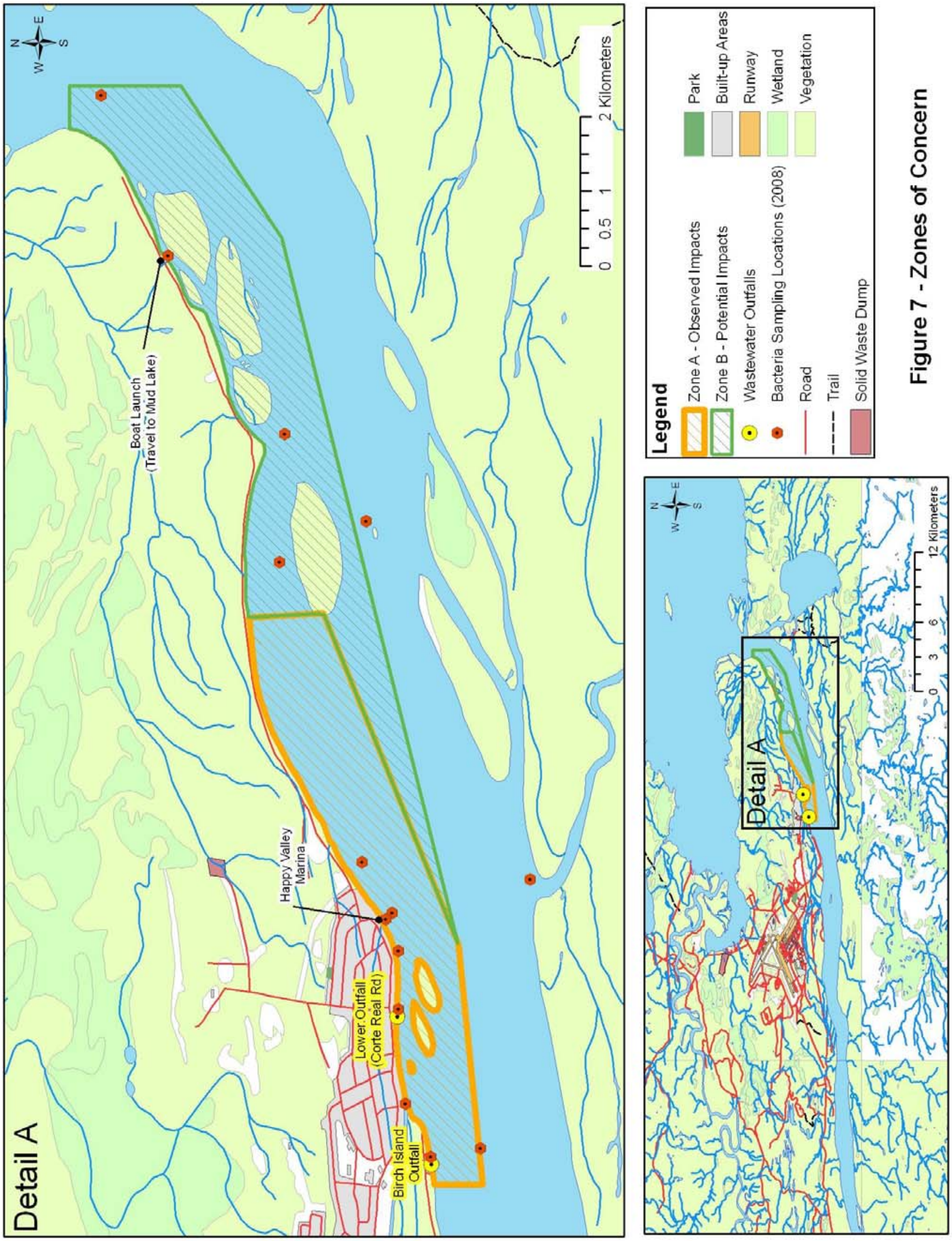


Figure 7 - Zones of Concern

MAY BE CONTAMINATED WITH SEWAGE" and it is posted in plain view for all those using the marina.

Sediment results in this zone did not show any impacts that can be attributed to wastewater impacts. As mentioned earlier, this does not mean that impacts to sediment do not occur in downstream reaches where deposition of impacted suspended material would occur (e.g. in Lake Melville). Impacts to biota were not considered in this zone since further study would be required to fully assess the impact to aquatic life.

3.5.2 Zone B – Potential Impacts from Wastewater Outfalls

Zone B extends from the southern and eastern edge of Zone A. The extent of Zone B is illustrated on Figure 7, however, as the Churchill River is a dynamic system and the main channel (i.e. deeper channel where major volume of flow is located) changes on a continual basis, the extent of Zone B would also need to be re-assessed on a routine basis.

Zone B represents the area where there is a potential for wastewater impacts and the results indicate there are residual impacts in water related to wastewater in this zone. Occasional exceedances of the CCME recreational water use guideline have occurred in this zone and there are indications that residual bacterial contamination still persists in this zone.

Zone B includes the main boat launch for travel to Mud Lake. This is a regularly used launch and its location is indicated on Figure 7. There are also several private boat launches and structures within Zone B.

Sediment results in this zone did not show any impacts that can be attributed to wastewater impacts. As mentioned earlier, this does not mean that impacts to sediment do not occur in downstream reaches where deposition of impacted suspended material would occur (e.g. in Lake Melville). Impacts to biota were not considered in this zone since further study would be required to fully assess the impact to aquatic life.

4 Conclusions

The following are the main conclusions of the study:

- Exceedances of the CCME recreational water use guidelines were observed for fecal coliforms in the Churchill River near HV-GB. Elevated fecal coliform concentrations were found downstream of the two sewage outfalls and are consistent with impacts expected downstream of raw sewage outfalls. Examination of the spatial pattern in fecal coliform concentrations indicate that the sewage impacts are not readily diluted by the large volumes of water within the Churchill River.

- Water sampling identified aluminum and iron concentrations that exceed the CCME Guidelines for the Protection of Aquatic Life – Freshwater. Elevated aluminum and iron concentrations are associated with suspended matter and are typical of Newfoundland and Labrador waters. Concentrations were consistent at all sampling locations and are not likely related to wastewater impacts. High levels of aluminum and iron have been recorded at the Upper Muskrat Station over the past thirty years with average aluminum and iron concentrations at this station exceeding CCME Guidelines (Envirodat).

- Water quality results for general chemistry, metals, and organics do not indicate a major change in water chemistry in the Churchill River from wastewater inputs in downstream reaches compared to upstream reaches above the two outfalls. Localized minor changes in major ion ratios, specific conductance and temperature give an indication of the dispersion patterns of the wastewater within the river in the vicinity of the outfalls. The key indicator parameters for wastewater inputs from the two sewage outfalls were fecal coliforms, major ion ratios, specific conductance and temperature.

- The sediment sampling did not identify impacts directly attributable to wastewater impacts in the immediate study area. Deposition of suspended material associated with wastewater impacts in downstream areas (e.g. Lake Melville) may locally impact aquatic ecosystems but this was beyond the scope of this assessment.

- Organic contaminants were detected in biota but the source and extent of these contaminants could not be determined based on the minimal samples collected. However, observed impacts (e.g. elevated PCBs and OC pesticides – specifically DDT) in the biota are more consistent with bio-accumulation from atmospheric pollutants and from activities upstream of the outfalls.

- By mapping the identified indicator parameters, a general understanding of the dispersion of the wastewater within the study area has been obtained. Wastewater is discharged from the two outfalls but does not readily mix with the flowing water. Results from the cruise data (Figure 4) and the spatial distribution of the fecal coliforms concentrations (Figure 6) indicate that impacts from wastewater and ultimately the fecal coliform concentrations are higher along the shore where velocities are lower than in the main channel. This further supports the findings of the longer term fecal coliform monitoring conducted by the province of Newfoundland and Labrador from 1981 to 1988 that consistently found higher concentrations along shore areas and in shallower areas downstream of the outfalls (NDEL, 1989).

- The Lower Outfall (Corte Real Road) is located in a deeper channel (> 10 metres at the time of study) which allows for more mixing and dilution of the wastewater. As a result, the impacts from the Lower Outfall appear to be less than from the upper outfall (Birch Island Outfall) where the flow velocities are lower and the river depth at the time of sampling was shallower (1.5 metres at NF03OE0043) thereby reducing the dilution and dispersion effects.

- Based on the results of this study, it was possible to identify two potential zones of impacts from the wastewater. Zone A (Figure 7) is located in the vicinity of the two outfalls and in the immediate downstream sections. Zone A represents an area where fecal coliforms measured exceeded the CCME guideline for recreational water use. Zone B (Figure 7) is an area downstream of Zone A where the potential for impacts from the wastewater (including exceedances of the recreational guideline) exists given the observed dispersion characteristics of the wastewater into the Churchill River near HV-GB. Zone B ends at the eastern edge of the study area at NF03OE0048. Areas to the east of NF03OE0048 may still have the potential for wastewater impacts but these areas were not studied during this assessment.

- Recreational water use, primarily associated with boating, occurs in areas downstream of the two sewage outfalls. Therefore, the potential for impaired recreational water use is greatest downstream of the outfalls and to the north of the main river channel (i.e. the main channel where discharge volume is greatest at deepest and highest flow velocities). Fecal coliforms are also an indicator of other water borne pathogens that commonly occur in untreated wastewater as well as many new and emerging contaminants (e.g. pharmaceutical and personal care products).

5 Recommendations

The following recommendations are provided based on the conclusions of the 2008 study:

- The ongoing discharge of untreated wastewater directly into the Churchill River has environmental and human health impacts, particularly with regard to bacterial contamination of the receiving waters. This impact has the potential to adversely impact both the environment at large and the health of the people using the impacted area for water-based recreational activities. Therefore the Town of HV-GB should move forward with building a sewage treatment system capable of removing solids and reducing pathogenic bacteria concentrations in the receiving waters. Furthermore, the treatment system should have an outlet into the Churchill River that should be located to optimize dilution and dispersion into the river.

- The two identified zones of concern should have management plans developed to minimize any risk to human health for people living in the area or for those who use the area for recreational activities (e.g. boating). At a minimum, Zone A should be restricted for swimming and wading and/or any activity requiring direct contact with the water (e.g. fishing). Boaters should be warned to avoid direct contact with water in this zone and to take necessary precautions. In Zone B all users should be warned to minimize contact with water and take precautionary measures to reduce the risk to human health.

- Additional signage should be erected to notify residents of the boundaries of the two zones of concern and restricted activities.

- An education program should be initiated to inform residents about the risks of contact with water impacted by raw sewage and also to identify precautions to take should contact with water be required. This program could include public information sessions, posters, pamphlets and signage.

- An ongoing monitoring program should be carried out to ensure conditions do not worsen. Such a monitoring program would involve collecting samples at regular sampling sites several times per year. The monitoring program should include sampling for fecal coliforms as these are the main indicator of wastewater impacts and are also the parameter that has an established guideline for recreational water use. This sampling program could be used to better define the zones of impact and any changes over time due to changes in river morphology.

- If a treatment system is built, monitoring of treated wastewater should adhere to the applicable guidelines and the zone of impacts should be re-defined based on treatment system design and effluent quality.

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7 Abbreviations

CCME	Canadian Council of Ministers of the Environment
EC	Environment Canada
HV-GB	Happy Valley-Goose Bay
NL	Newfoundland and Labrador

Appendix A

Water Chemistry Results

Table A.1 - Water Sampling Results - General Chemistry

PARAMETER	Units	MDL	CCME Guidelines (FAL)	NF03OE0040	NF03OE0041	NF03OE0042	NF03OE0043
				21/Aug/2008	21/Aug/2008	22/Aug/2008	22/Aug/2008
TOTAL PHOSPHORUS	mg/L	0.002	-	0.026	0.032	0.029	0.029
TOTAL NITROGEN	mg/L	0.01	-	0.14	0.14	0.12	0.14
NITRATE (AS NITROGEN)	mg/L	0.02	2.7	nd	nd	nd	nd
SODIUM	mg/L	-	-	0.77	0.76	0.76	1.24
POTASSIUM	mg/L	0.1	-	0.5	0.5	0.5	0.5
CALCIUM	mg/L	0.01	-	2.44	2.5	2.43	2.49
MAGNESIUM	mg/L	0.05	-	1.11	1.13	1.1	1.18
CHLORIDE	mg/L	0.1	-	0.37	0.35	0.35	0.98
SULPHATE	mg/L	0.1	-	0.94	0.94	0.95	0.99
TOTAL ORGANIC CARBON	mg/L	0.2	-	3.6	3.5	3.8	3.6
TOTAL INORGANIC CARBON	mg/L	0.5	-	2.2	2.2	2.2	2.3
COLOUR - APPARENT	Hazen Units	5	-	19	18	20	19
SPECIFIC CONDUCTANCE - LAB	µS/cm	-	-	22.2	22.1	21.9	24.9
SPECIFIC CONDUCTANCE - FIELD	µS/cm	-	-	22	22	22	25
PH - LAB	pH Units	-	6.5-9.0	7.22	7.24	7.23	7.25
PH - FIELD	pH Units	-	6.5-9.0	7.26	7.29	7.12	7.15
TEMPERATURE	Degrees Celsius	-	-	16.4	16.43	16.96	18.17
DISSOLVED OXYGEN	mg/L	-	6.5[3]	10.9	10.82	10.79	10.5
DISSOLVED OXYGEN (% SATURATION)	%	-	-	111.3	110.6	111.6	111.3
ALKALINITY- GRANULAR	mg/L as $CaCO_3$	-	-	8.77	8.73	8.5	9.08
ALKALINITY - TOTAL	mg/L as $CaCO_3$	20	-	nd	nd	nd	nd
TURBIDITY - LAB	NTU	-	-	3.5	2.8	2.5	2.8

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; mg/L = milligrams per litre; NTU = Nephelometric Turbidity Units; µS/cm = microSiemens per centimetre; $CaCO_3$ = calcium carbonate; Fdup = field duplicate

2. CCME Guidelines (FAL) = CCME Water Quality Guidelines for the Protection Of Aquatic Life - Freshwater, updated 2007 (http://www.ccme.ca/assets/pdf/aql_summary_7.1_en.pdf accessed January 14, 2009)

3. CCME Cold-water guideline for other life stages.

Table A.1 - Water Sampling Results - General Chemistry

PARAMETER	Units	MDL	CCME Guidelines (FAL)	NF03OE0043 (Fdup)	NF03OE0044	NF03OE0045	NF03OE0046
				22/Aug/2008	22/Aug/2008	21/Aug/2008	21/Aug/2008
TOTAL PHOSPHORUS	mg/L	0.002	-	0.029	0.029	0.027	0.026
TOTAL NITROGEN	mg/L	0.01	-	0.14	0.14	0.14	0.08
NITRATE (AS NITROGEN)	mg/L	0.02	2.7	nd	nd	nd	nd
SODIUM	mg/L	-	-	1.1	0.98	0.81	0.8
POTASSIUM	mg/L	0.1	-	0.5	0.6	0.5	0.6
CALCIUM	mg/L	0.01	-	2.55	2.45	2.44	2.44
MAGNESIUM	mg/L	0.05	-	1.17	1.17	1.14	1.13
CHLORIDE	mg/L	0.1	-	0.93	0.69	0.42	0.41
SULPHATE	mg/L	0.1	-	0.95	0.96	0.94	0.94
TOTAL ORGANIC CARBON	mg/L	0.2	-	3.6	3.7	3.5	3.5
TOTAL INORGANIC CARBON	mg/L	0.5	-	2.2	2.1	2.2	2.2
COLOUR - APPARENT	Hazen Units	5	-	19	18	22	19
SPECIFIC CONDUCTANCE - LAB	µS/cm	-	-	24.9	23.5	22.4	22.3
SPECIFIC CONDUCTANCE - FIELD	µS/cm	-	-	25	24	22	22
PH - LAB	pH Units	-	6.5-9.0	7.28	7.24	7.24	7.23
PH - FIELD	pH Units	-	6.5-9.0	7.15	7.11	7.19	7.15
TEMPERATURE	Degrees Celsius	-	-	18.17	17.36	16.9	16.9
DISSOLVED OXYGEN	mg/L	-	6.5[3]	10.5	10.62	10.5	10.53
DISSOLVED OXYGEN (% SATURATION)	%	-	-	111.3	110.7	108.4	108.7
ALKALINITY- GRANULAR	mg/L as $CaCO_3$	-	-	8.95	8.81	8.99	8.83
ALKALINITY - TOTAL	mg/L as $CaCO_3$	20	-	nd	nd	nd	nd
TURBIDITY - LAB	NTU	-	-	2.8	2.7	2.9	2.8

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; mg/L = milligrams per litre; NTU = Nephelometric Turbidity Units; µS/cm = microSiemens per centimetre; $CaCO_3$ = calcium carbonate; Fdup = field duplicate

2. CCME Guidelines (FAL) = CCME Water Quality Guidelines for the Protection Of Aquatic Life - Freshwater, updated 2007 (http://www.ccme.ca/assets/pdf/aql_summary_7.1_en.pdf accessed January 14, 2009)

3. CCME Cold-water guideline for other life stages.

Table A.1 - Water Sampling Results - General Chemistry

PARAMETER	Units	MDL	CCME Guidelines (FAL)	NF03OE0047	NF03OE0048	Field Blank
				22/Aug/2008	21/Aug/2008	22/Aug/2008
TOTAL PHOSPHORUS	mg/L	0.002	-	0.029	0.022	0.002
TOTAL NITROGEN	mg/L	0.01	-	0.14	0.16	nd
NITRATE (AS NITROGEN)	mg/L	0.02	2.7	nd	nd	nd
SODIUM	mg/L	-	-	0.9	0.86	0.02
POTASSIUM	mg/L	0.1	-	0.6	0.6	nd
CALCIUM	mg/L	0.01	-	2.51	2.5	nd
MAGNESIUM	mg/L	0.05	-	1.14	1.13	nd
CHLORIDE	mg/L	0.1	-	0.58	0.48	nd
SULPHATE	mg/L	0.1	-	0.93	0.97	nd
TOTAL ORGANIC CARBON	mg/L	0.2	-	3.8	3.7	nd
TOTAL INORGANIC CARBON	mg/L	0.5	-	2.2	2.2	nd
COLOUR - APPARENT	Hazen Units	5	-	20	19	nd
SPECIFIC CONDUCTANCE - LAB	µS/cm	-	-	23.2	23.2	0.9
SPECIFIC CONDUCTANCE - FIELD	µS/cm	-	-	23	23	-
PH - LAB	pH Units	-	6.5-9.0	7.27	7.27	5.69
PH - FIELD	pH Units	-	6.5-9.0	7.17	7.18	-
TEMPERATURE	Degrees Celsius	-	-	16.52	16.45	-
DISSOLVED OXYGEN	mg/L	-	6.5[3]	10.65	10.43	-
DISSOLVED OXYGEN (% SATURATION)	%	-	-	109.1	106.7	-
ALKALINITY- GRANULAR	mg/L as $CaCO_3$	-	-	8.77	8.79	0.08
ALKALINITY - TOTAL	mg/L as $CaCO_3$	20	-	nd	nd	nd
TURBIDITY - LAB	NTU	-	-	3	3	0.1

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; mg/L = milligrams per litre; NTU = Nephelometric Turbidity Units; µS/cm = microSiemens per centimetre; $CaCO_3$ = calcium carbonate; Fdup = field duplicate

2. CCME Guidelines (FAL) = CCME Water Quality Guidelines for the Protection Of Aquatic Life - Freshwater, updated 2007 (http://www.ccme.ca/assets/pdf/aql_summary_7.1_en.pdf accessed January 14, 2009)

3. CCME Cold-water guideline for other life stages.

Table A.2 - Water Sampling Results - Metals

PARAMETER	Units	MDL	CCME Guidelines (FAL)	NF03OE0040 21/Aug/2008	NF03OE0041 21/Aug/2008	NF03OE0042 22/Aug/2008	NF03OE0043 22/Aug/2008
ALUMINUM	µg/L	4	100 (pH > 6.5)	**471**	**508**	**454**	**467**
ANTIMONY	µg/L	0.1	-	nd	nd	nd	nd
ARSENIC	µg/L	0.1	5	nd	0.1	nd	nd
BARIUM	µg/L	1	-	14	14	14	14
BERYLLIUM	µg/L	0.1	-	nd	nd	nd	nd
CADMIUM	µg/L	0.1	0.017	nd	nd	nd	nd
CHROMIUM	µg/L	0.4	1 (Cr III); 8.9 (Cr VI)	1.2	1.3	1.2	1.2
COBALT	µg/L	0.1	-	0.4	0.4	0.4	0.4
COPPER	µg/L	0.2	2	1.7	1.8	1.7	1.8
IRON	mg/L	0.02	0.3	**0.54**	**0.59**	**0.54**	**0.57**
LEAD	µg/L	0.1	1	0.2	0.3	0.2	0.2
MANGANESE	µg/L	2	-	20	22	20	23
MERCURY (LOW LEVEL IN WATER)	ng/L	0.3	26	1.4	1.2	4.4	1.2
MOLYBDENUM	µg/L	0.1	73	nd	nd	nd	nd
NICKEL	µg/L	0.1	25	1.2	1.2	1.1	1.2
SELENIUM	µg/L	0.1	1	nd	nd	nd	nd
SILVER	µg/L	0.1	0.1	nd	nd	nd	nd
STRONTIUM	µg/L	1	-	14	15	14	15
THALLIUM	µg/L	0.1	0.8	nd	nd	nd	nd
TIN	µg/L	0.1	-	nd	nd	nd	nd
TITANIUM	µg/L	0.1	-	37.5	41.7	36.7	38.1
URANIUM	µg/L	0.1	-	nd	nd	nd	nd
VANADIUM	µg/L	0.1	-	1.1	1.3	1.1	1.1
ZINC	µg/L	0.3	30	2.9	2.3	2.2	2.2

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; ng/L = nanograms per litre

2. CCME Guidelines (FAL) = CCME Water Quality Guidelines for the Protection Of Aquatic Life - Freshwater, updated 2007 (http://www.ccme.ca/assets/pdf/aql_summary_7.1_en.pdf accessed January 14, 2009)

3. Bolding indicates a guideline exceedance.

Table A.2 - Water Sampling Results - Metals

PARAMETER	Units	MDL	CCME Guidelines (FAL)	NF03OE0043 (Fdup) 22/Aug/2008	NF03OE0044 22/Aug/2008	NF03OE0045 21/Aug/2008	NF03OE0046 21/Aug/2008
ALUMINUM	**µg/L**	**4**	**100 (pH > 6.5)**	**495**	**489**	**489**	**482**
ANTIMONY	**µg/L**	**0.1**	**-**	nd	nd	nd	nd
ARSENIC	**µg/L**	**0.1**	**5**	nd	0.1	0.1	0.1
BARIUM	**µg/L**	**1**	**-**	15	15	14	14
BERYLLIUM	**µg/L**	**0.1**	**-**	nd	nd	nd	nd
CADMIUM	**µg/L**	**0.1**	**0.017**	nd	nd	nd	nd
CHROMIUM	**µg/L**	**0.4**	**1 (Cr III); 8.9 (Cr VI)**	1.2	1.3	1.3	1.2
COBALT	**µg/L**	**0.1**	**-**	0.4	0.4	0.4	0.4
COPPER	**µg/L**	**0.2**	**2**	1.7	1.8	1.7	1.8
IRON	**mg/L**	**0.02**	**0.3**	**0.6**	**0.58**	**0.56**	**0.56**
LEAD	**µg/L**	**0.1**	**1**	0.2	0.2	0.2	0.2
MANGANESE	**µg/L**	**2**	**-**	23	21	21	20
MERCURY (LOW LEVEL IN WATER)	**ng/L**	**0.3**	**26**	1.4	1.6	1.5	2.3
MOLYBDENUM	**µg/L**	**0.1**	**73**	nd	nd	nd	nd
NICKEL	**µg/L**	**0.1**	**25**	1.1	1.2	1.2	1.3
SELENIUM	**µg/L**	**0.1**	**1**	nd	nd	nd	nd
SILVER	**µg/L**	**0.1**	**0.1**	nd	nd	nd	nd
STRONTIUM	**µg/L**	**1**	**-**	15	15	15	14
THALLIUM	**µg/L**	**0.1**	**0.8**	nd	nd	nd	nd
TIN	**µg/L**	**0.1**	**-**	nd	nd	nd	nd
TITANIUM	**µg/L**	**0.1**	**-**	38.8	39.9	40.2	39.4
URANIUM	**µg/L**	**0.1**	**-**	nd	nd	nd	nd
VANADIUM	**µg/L**	**0.1**	**-**	1.2	1.2	1.2	1.2
ZINC	**µg/L**	**0.3**	**30**	2.1	2.2	2.2	2.2

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; ng/L = nanograms per litre

2. CCME Guidelines (FAL) = CCME Water Quality Guidelines for the Protection Of Aquatic Life - Freshwater, updated 2007 (http://www.ccme.ca/assets/pdf/aql_summary_7.1_en.pdf accessed January 14, 2009)

3. Bolding indicates a guideline exceedance.

Table A.2 - Water Sampling Results - Metals

PARAMETER	Units	MDL	CCME Guidelines (FAL)	NF03OE0047 22/Aug/2008	NF03OE0048 21/Aug/2008	Field Blank 22/Aug/2008	Rinsate 22/Aug/2008
ALUMINUM	**µg/L**	**4**	**100 (pH > 6.5)**	**478**	**475**	nd	nd
ANTIMONY	**µg/L**	**0.1**	**-**	nd	nd	nd	nd
ARSENIC	**µg/L**	**0.1**	**5**	nd	nd	nd	nd
BARIUM	**µg/L**	**1**	**-**	14	14	nd	nd
BERYLLIUM	**µg/L**	**0.1**	**-**	nd	nd	nd	nd
CADMIUM	**µg/L**	**0.1**	**0.017**	nd	nd	nd	**8.7**
CHROMIUM	**µg/L**	**0.4**	**1 (Cr III); 8.9 (Cr VI)**	1.2	1.2	nd	nd
COBALT	**µg/L**	**0.1**	**-**	0.4	0.4	nd	nd
COPPER	**µg/L**	**0.2**	**2**	1.7	1.8	nd	**2.8**
IRON	**mg/L**	**0.02**	**0.3**	**0.57**	**0.57**	nd	nd
LEAD	**µg/L**	**0.1**	**1**	0.3	0.2	nd	nd
MANGANESE	**µg/L**	**2**	**-**	21	20	nd	nd
MERCURY (LOW LEVEL IN WATER)	**ng/L**	**0.3**	**26**	1.6	1.4	nd	-
MOLYBDENUM	**µg/L**	**0.1**	**73**	nd	nd	nd	nd
NICKEL	**µg/L**	**0.1**	**25**	1.2	1.2	nd	0.7
SELENIUM	**µg/L**	**0.1**	**1**	nd	nd	nd	nd
SILVER	**µg/L**	**0.1**	**0.1**	nd	nd	nd	nd
STRONTIUM	**µg/L**	**1**	**-**	15	15	nd	nd
THALLIUM	**µg/L**	**0.1**	**0.8**	nd	nd	nd	nd
TIN	**µg/L**	**0.1**	**-**	nd	nd	nd	nd
TITANIUM	**µg/L**	**0.1**	**-**	38.7	38.3	nd	nd
URANIUM	**µg/L**	**0.1**	**-**	nd	nd	nd	nd
VANADIUM	**µg/L**	**0.1**	**-**	1.1	1.2	nd	nd
ZINC	**µg/L**	**0.3**	**30**	2.1	2	nd	16.1

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; ng/L = nanograms per litre

2. CCME Guidelines (FAL) = CCME Water Quality Guidelines for the Protection Of Aquatic Life - Freshwater, updated 2007 (http://www.ccme.ca/assets/pdf/aql_summary_7.1_en.pdf accessed January 14, 2009)

3. Bolding indicates a guideline exceedance.

Table A.3 - Water Sampling Results - Fecal Coliforms (*E. coli*)

Sample ID	Sampling Location		Location Description	Date and Time	Sample Type	Units	FECAL COLIFORMS (*E. COLI*)
	Latitude	Longitude					
B1	53.27924	-60.27654	Mouth of Traverspine River - South Side of Churchill River	24/Aug/08 11:15	Discrete	cfu/100ml	3
B2	53.29896	-60.23350	Near NF03OE0046	24/Aug/08 11:35	Discrete	cfu/100ml	4
B3	53.30871	-60.22301	In main channel	24/Aug/08 11:55	Discrete	cfu/100ml	10
B4	53.32273	-60.20166	At Mud Lake Road boat launch	24/Aug/08 12:00	Discrete	cfu/100ml	200
B5	53.33078	-60.18237	At the mouth of the Churchill River	24/Aug/08 12:10	Discrete	cfu/100ml	26
B6	53.30934	-60.23846	Near NF03OE0045	24/Aug/08 12:20	Discrete	cfu/100ml	19
B7	53.29944	-60.27446	Approx. 500 metres downstream from HV marina	24/Aug/08 12:30	Discrete	cfu/100ml	200
B8	53.29582	-60.28058	Approx. 100 metres South of HV marina shoreline	24/Aug/08 12:40	Discrete	cfu/100ml	14
B9	53.29657	-60.28133	At HV marina boat launch area	24/Aug/08 12:44	Discrete	cfu/100ml	**1100**
B10	53.29657	-60.28133	At HV marina boat launch area (field duplicate)	24/Aug/08 12:45	Duplicate	cfu/100ml	**600**
B11	53.29507	-60.28513	Between NF03OE0044 and HV marina	24/Aug/08 12:50	Discrete	cfu/100ml	**1000**
B12	53.28521	-60.30883	Upstream of Birch Island Outfall in main channel	24/Aug/08 12:53	Discrete	cfu/100ml	0
B13	53.29427	-60.30353	At NF03OE0049 location at downstream end of Birch Island	24/Aug/08 13:05	Discrete	cfu/100ml	**30000**
B14	53.2912	-60.30990	At Birch Island Outfall	24/Aug/08 13:10	Discrete	cfu/100ml	10
B15	53.29505	-60.29211	At Lower Outfall (Corte Real Road)	24/Aug/08 13:20	Discrete	cfu/100ml	**2000**
B16	53.27989	-60.35994	Upstream of Birch Island	24/Aug/08 14:10	Discrete	cfu/100ml	2
B17 (Field Blank)	n/a	n/a	Field Blank (bottled water)	24/Aug/08 14:30	Blank	cfu/100ml	0

Notes:

1. Results assessed against the Guidelines for Canadian Recreational Water Quality, Health Canada 1992; Maximum Limits. The geometric mean of at least 5 samples, taken during a period not to exceed 30 days, should not exceed 200 E. coli/100ml. Resampling should be performed when any sample exceeds 400 E. coli/100ml. Samples exceeding 200 cfu/100 ml are bolded.

2. cfu/100ml = colony forming units per 100 millilitres; HV = Happy Valley

3. All samples taken at 0.3 metres below surface.

Table A.4 - Water Sampling Results - Polycyclic Aromatic Hydrocarbons (PAHs)

PARAMETER	Units	MDL	CCME Guidelines (FAL)	NF03OE0040	NF03OE0041	NF03OE0042	NF03OE0043	NF03OE0043 (Fdup)
				21/Aug/2008	21/Aug/2008	22/Aug/2008	22/Aug/2008	22/Aug/2008
INDENE	ng/L	5.05	-	nd	nd	nd	nd	nd
1,2,3,4-TETRAHYDRONAPHTHALENE	ng/L	5.71	-	nd	nd	nd	nd	nd
NAPHTHALENE	ng/L	5.8	1100	nd	nd	nd	nd	nd
2-METHYLNAPHTHALENE	ng/L	7.59	-	nd	nd	nd	nd	nd
1-METHYLNAPHTHALENE	ng/L	6.73	-	nd	nd	nd	nd	nd
2-CHLORONAPHTHALENE	ng/L	6.65	-	nd	nd	nd	nd	nd
ACENAPHTHYLENE	ng/L	6.53	-	nd	nd	nd	nd	nd
ACENAPHTHENE	ng/L	5.17	5800	nd	nd	nd	nd	nd
FLUORENE	ng/L	6.38	3000	nd	nd	nd	nd	nd
PHENANTHRENE	ng/L	6.2	400	nd	nd	nd	nd	nd
ANTHRACENE	ng/L	6.12	12	nd	nd	nd	nd	nd
FLUORANTHENE	ng/L	4.08	40	nd	nd	nd	nd	nd
PYRENE	ng/L	3.93	25	nd	nd	nd	nd	nd
BENZO(A)ANTHRACENE	ng/L	9.96	18	nd	nd	nd	nd	nd
CHRYSENE	ng/L	2.95	-	nd	nd	nd	nd	nd
BENZO(B)FLUORANTHENE	ng/L	10	-	nd	nd	nd	nd	nd
BENZO(K)FLUORANTHENE	ng/L	8.63	-	nd	nd	nd	nd	nd
BENZO(E)PYRENE	ng/L	8.7	-	nd	nd	nd	nd	nd
BENZO(A)PYRENE	ng/L	9.42	15	nd	nd	nd	nd	nd
PERYLENE	ng/L	13.4	-	nd	nd	nd	nd	nd
INDENO(1,2,3-CD)PYRENE	ng/L	18	-	nd	nd	nd	nd	nd
DIBENZ(A,H)ANTHRACENE	ng/L	25.1	-	nd	nd	nd	nd	nd
BENZO(G,H,I)PERYLENE	ng/L	17.1	-	nd	nd	nd	nd	nd
NAPHTHALENE-D8	%	-	-	35 C	47 C	107 C	52 C	68 C
FLUORENE-D10	%	-	-	62 C	62 C	133 C	Sus Int C	85 C
PYRENE-D10	%	-	-	61 C	63 C	127 C	Sus Int C	89 C
D-PERYLENE	%	-	-	47 C	89 C	112 C	Sus Int C	139 C
DIBENZOTHIOPENE	ng/L	8.16	-	nd	nd	nd	nd	nd
RETENE	ng/L	13.6	-	nd	nd	nd	nd	nd

Notes:

1. PAHs - polycyclic aromatic hydrocarbons; MDL = method detection limit; nd = not detected at method detection limit; ng/L = nanograms per litre; Fdup = field duplicate

2. CCME Guidelines (FAL) = CCME Water Quality Guidelines for the Protection Of Aquatic Life - Freshwater, updated 2007 (http://www.ccme.ca/assets/pdf/aql_summary_7.1_en.pdf accessed January 14, 2009)

Table A.4 - Water Sampling Results - Polycyclic Aromatic Hydrocarbons (PAHs)

PARAMETER	Units	MDL	CCME Guidelines (FAL)	NF03OE0044	NF03OE0045	NF03OE0046	NF03OE0047	NF03OE0048
				22/Aug/2008	21/Aug/2008	21/Aug/2008	22/Aug/2008	21/Aug/2008
INDENE	ng/L	5.05	-	nd	nd	nd	nd	nd
1,2,3,4-TETRAHYDRONAPHTHALENE	ng/L	5.71	-	nd	nd	nd	nd	nd
NAPHTHALENE	ng/L	5.8	1100	nd	nd	nd	nd	nd
2-METHYLNAPHTHALENE	ng/L	7.59	-	nd	nd	nd	nd	nd
1-METHYLNAPHTHALENE	ng/L	6.73	-	nd	nd	nd	nd	nd
2-CHLORONAPHTHALENE	ng/L	6.65	-	nd	nd	nd	nd	nd
ACENAPHTHYLENE	ng/L	6.53	-	nd	nd	nd	nd	nd
ACENAPHTHENE	ng/L	5.17	5800	nd	nd	nd	nd	nd
FLUORENE	ng/L	6.38	3000	nd	nd	nd	nd	nd
PHENANTHRENE	ng/L	6.2	400	nd	nd	nd	nd	nd
ANTHRACENE	ng/L	6.12	12	nd	nd	nd	nd	nd
FLUORANTHENE	ng/L	4.08	40	nd	nd	nd	nd	nd
PYRENE	ng/L	3.93	25	nd	nd	nd	nd	nd
BENZO(A)ANTHRACENE	ng/L	9.96	18	nd	nd	nd	nd	nd
CHRYSENE	ng/L	2.95	-	nd	nd	nd	nd	nd
BENZO(B)FLUORANTHENE	ng/L	10	-	nd	nd	nd	nd	nd
BENZO(K)FLUORANTHENE	ng/L	8.63	-	nd	nd	nd	nd	nd
BENZO(E)PYRENE	ng/L	8.7	-	nd	nd	nd	nd	nd
BENZO(A)PYRENE	ng/L	9.42	15	nd	nd	nd	nd	nd
PERYLENE	ng/L	13.4	-	nd	nd	nd	nd	nd
INDENO(1,2,3-CD)PYRENE	ng/L	18	-	nd	nd	nd	nd	nd
DIBENZ(A,H)ANTHRACENE	ng/L	25.1	-	nd	nd	nd	nd	nd
BENZO(G,H,I)PERYLENE	ng/L	17.1	-	nd	nd	nd	nd	nd
NAPHTHALENE-D8	%	-	-	56 C	58 C	59 C	61 C	2 C
FLUORENE-D10	%	-	-	81 C	85 C	Sus Int C	Sus Int C	2 C
PYRENE-D10	%	-	-	84 C	85 C	Sus Int C	Sus Int C	12 C
D-PERYLENE	%	-	-	135 C	129 C	Sus Int C	Sus Int C	88 C
DIBENZOTHIOPENE	ng/L	8.16	-	nd	nd	nd	nd	nd
RETENE	ng/L	13.6	-	nd	nd	nd	nd	nd

Notes:

1. PAHs - polycyclic aromatic hydrocarbons; MDL = method detection limit; nd = not detected at method detection limit; ng/L = nanograms per litre; Fdup = field duplicate

2. CCME Guidelines (FAL) = CCME Water Quality Guidelines for the Protection Of Aquatic Life - Freshwater, updated 2007 (http://www.ccme.ca/assets/pdf/aql_summary_7.1_en.pdf accessed January 14, 2009)

Table A.4 - Water Sampling Results - Polycyclic Aromatic Hydrocarbons (PAHs)

PARAMETER	Units	MDL	CCME Guidelines (FAL)	Field Blank	Rinsate
				22/Aug/2008	22/Aug/2008
INDENE	ng/L	5.05	-	nd	nd
1,2,3,4-TETRAHYDRONAPHTHALENE	ng/L	5.71	-	nd	nd
NAPHTHALENE	ng/L	5.8	1100	nd	nd
2-METHYLNAPHTHALENE	ng/L	7.59	-	nd	nd
1-METHYLNAPHTHALENE	ng/L	6.73	-	nd	nd
2-CHLORONAPHTHALENE	ng/L	6.65	-	nd	nd
ACENAPHTHYLENE	ng/L	6.53	-	nd	nd
ACENAPHTHENE	ng/L	5.17	5800	nd	nd
FLUORENE	ng/L	6.38	3000	nd	nd
PHENANTHRENE	ng/L	6.2	400	nd	nd
ANTHRACENE	ng/L	6.12	12	nd	nd
FLUORANTHENE	ng/L	4.08	40	nd	nd
PYRENE	ng/L	3.93	25	nd	nd
BENZO(A)ANTHRACENE	ng/L	9.96	18	nd	nd
CHRYSENE	ng/L	2.95	-	nd	nd
BENZO(B)FLUORANTHENE	ng/L	10	-	nd	nd
BENZO(K)FLUORANTHENE	ng/L	8.63	-	nd	nd
BENZO(E)PYRENE	ng/L	8.7	-	nd	nd
BENZO(A)PYRENE	ng/L	9.42	15	nd	nd
PERYLENE	ng/L	13.4	-	nd	nd
INDENO(1,2,3-CD)PYRENE	ng/L	18	-	nd	nd
DIBENZ(A,H)ANTHRACENE	ng/L	25.1	-	nd	nd
BENZO(G,H,I)PERYLENE	ng/L	17.1	-	nd	nd
NAPHTHALENE-D8	%	-	-	58 C	56 C
FLUORENE-D10	%	-	-	Sus Int C	79 C
PYRENE-D10	%	-	-	Sus Int C	77 C
D-PERYLENE	%	-	-	Sus Int C	94 C
DIBENZOTHIOPENE	ng/L	8.16	-	nd	nd
RETENE	ng/L	13.6	-	nd	nd

Notes:

1. PAHs - polycyclic aromatic hydrocarbons; MDL = method detection limit; nd = not detected at method detection limit; ng/L = nanograms per litre; Fdup = field duplicate

2. CCME Guidelines (FAL) = CCME Water Quality Guidelines for the Protection Of Aquatic Life - Freshwater, updated 2007 (http://www.ccme.ca/assets/pdf/aql_summary_7.1_en.pdf accessed January 14, 2009)

Appendix B

Sediment Chemistry Results

Table B.1 - Sediment Sampling Results - Metals

PARAMETER	Units	MDL	CCME Guidelines		NF03OE0040	NF03OE0041	NF03OE0042	NF03OE0043	NF03OE0043 (Dup)
			ISQG	PEL	21/Aug/2008	21/Aug/2008	22/Aug/2008	22/Aug/2008	22/Aug/2008
ALUMINUM	mg/kg	-	-	-	2951	2919	5350	3416	3521
ANTIMONY	mg/kg	5	-	-	nd	nd	nd	nd	nd
ARSENIC	mg/kg	1	5.9	17	nd	nd	nd	nd	nd
BARIUM	mg/kg	-	-	-	27.8	23.1	57.5	32.7	33.8
BERYLLIUM	mg/kg	-	-	-	0.1	0.1	0.2	0.1	0.1
CADMIUM	mg/kg	-	0.6	3.5	0.14	0.3	0.24	0.28	0.15
CHROMIUM	mg/kg	-	37.3	90	7.8	7.7	12.3	7.1	7.3
COBALT	mg/kg	-	-	-	3	3.1	4.9	3.3	3.3
COPPER	mg/kg	-	35.7	197	4.79	4.65	7.28	4.77	4.37
IRON	mg/kg	-	-	-	4010	4718	6784	4597	4650
LEAD	mg/kg	2.5	35	91.3	nd	nd	nd	nd	nd
MANGANESE	mg/kg	-	-	-	122.7	130.3	185.9	108.6	109
MERCURY	mg/kg	0.02	0.17	0.486	nd	nd	nd	nd	nd
MOLYBDENUM	mg/kg	0.5	-	-	nd	nd	nd	nd	nd
NICKEL	mg/kg	-	-	-	8.04	8.81	10.42	7.04	7.34
SELENIUM	mg/kg	5	-	-	nd	nd	nd	nd	nd
SILVER	mg/kg	0.25	-	-	nd	nd	nd	nd	nd
STRONTIUM	mg/kg	-	-	-	5.15	5.69	11.26	6.68	7.29
THALLIUM	mg/kg	2.5	-	-	nd	nd	nd	nd	nd
TIN	mg/kg	2.5	-	-	nd	nd	nd	nd	nd
TITANIUM	mg/kg	-	-	-	244.9	261.3	532.1	348	323
VANADIUM	mg/kg	-	-	-	7.1	8.9	14.3	8.7	9.2
ZINC	mg/kg	-	123	315	15	15.2	24.9	17.2	17.1

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; mg/kg = milligrams per kilogram

Life, updated 2002 (http://www.ccme.ca/assets/pdf/sedqg_summary_table.pdf accessed January 8, 2009)

3. ISQG = Interim Freshwater Sediment Quality Guidelines (dry weight); PEL = Probable Effect Levels (dry weight)

4. ISQG guideline exceedances bolded; PEL guideline exceedances shaded

Table B.1 - Sediment Sampling Results - Metals

PARAMETER	Units	MDL	CCME Guidelines		NF03OE0044	NF03OE0045	NF03OE0046	NF03OE0047	NF03OE0048
			ISQG	PEL	22/Aug/2008	21/Aug/2008	21/Aug/2008	22/Aug/2008	21/Aug/2008
ALUMINUM	mg/kg	-	-	-	4480	5129	3242	4881	3681
ANTIMONY	mg/kg	5	-	-	nd	nd	nd	nd	nd
ARSENIC	mg/kg	1	5.9	17	nd	nd	nd	nd	nd
BARIUM	mg/kg	-	-	-	44.6	55.1	39.2	55.9	31.5
BERYLLIUM	mg/kg	-	-	-	0.2	0.2	0.1	0.2	0.1
CADMIUM	mg/kg	-	0.6	3.5	0.23	0.2	0.25	0.25	0.15
CHROMIUM	mg/kg	-	37.3	90	10.1	10.8	5.8	11.5	6.8
COBALT	mg/kg	-	-	-	4.3	4.9	3	4.5	3.4
COPPER	mg/kg	-	35.7	197	5.14	5.37	3.99	6.16	4.83
IRON	mg/kg	-	-	-	6159	6291	3664	6323	4547
LEAD	mg/kg	2.5	35	91.3	nd	nd	nd	nd	nd
MANGANESE	mg/kg	-	-	-	146.2	169.9	109.9	152.4	128.5
MERCURY	mg/kg	0.02	0.17	0.486	nd	nd	nd	nd	nd
MOLYBDENUM	mg/kg	0.5	-	-	nd	nd	nd	nd	nd
NICKEL	mg/kg	-	-	-	8.76	10.36	6.77	9.08	8.42
SELENIUM	mg/kg	5	-	-	nd	nd	nd	nd	nd
SILVER	mg/kg	0.25	-	-	nd	nd	nd	nd	nd
STRONTIUM	mg/kg	-	-	-	9.19	8.29	6.21	10.75	6.8
THALLIUM	mg/kg	2.5	-	-	nd	nd	nd	nd	nd
TIN	mg/kg	2.5	-	-	nd	nd	nd	nd	nd
TITANIUM	mg/kg	-	-	-	457.6	531.9	286.5	523.7	287.3
VANADIUM	mg/kg	-	-	-	12.1	12.3	6.8	14	8
ZINC	mg/kg	-	123	315	21.5	26.2	17.2	23.1	18.1

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; mg/kg = milligrams per kilogram

Life, updated 2002 (http://www.ccme.ca/assets/pdf/sedqg_summary_table.pdf accessed January 8, 2009)

3. ISQG = Interim Freshwater Sediment Quality Guidelines (dry weight); PEL = Probable Effect Levels (dry weight)

4. ISQG guideline exceedances bolded; PEL guideline exceedances shaded

Table B.2 - Sediment Sampling Results - Polycyclic Aromatic Hydrocarbons (PAHs)

PARAMETER	Units	MDL	CCME Guidelines		NF03OE0040	NF03OE0041	NF03OE0042	NF03OE0043
			ISQG	PEL	21/Aug/2008	21/Aug/2008	22/Aug/2008	22/Aug/2008
INDENE	ng/g	142	-	-	nd	nd	nd	nd
1,2,3,4-TETRAHYDRONAPHTHALENE	ng/g	132	-	-	nd	nd	nd	nd
NAPHTHALENE	ng/g	81.5	34.6	391	nd	nd	nd	nd
2-METHYLNAPHTHALENE	ng/g	118	20.2	201	nd	nd	nd	nd
1-METHYLNAPHTHALENE	ng/g	132	-	-	nd	nd	nd	nd
2-CHLORONAPHTHALENE	ng/g	126	-	-	nd	nd	nd	nd
ACENAPHTHYLENE	ng/g	136	5.87	128	nd	nd	nd	nd
ACENAPHTHENE	ng/g	187	6.71	88.9	nd	nd	nd	nd
FLUORENE	ng/g	174	21.2	144	nd	nd	nd	nd
PHENANTHRENE	ng/g	163	41.9	515	nd	nd	nd	nd
ANTHRACENE	ng/g	81.5	46.9	245	nd	nd	nd	nd
FLUORANTHENE	ng/g	86.2	111	2355	nd	nd	nd	nd
PYRENE	ng/g	94.2	53	875	nd	nd	nd	nd
BENZO(A)ANTHRACENE	ng/g	81.5	31.7	385	nd	nd	nd	nd
CHRYSENE	ng/g	81.5	57.1	862	nd	nd	nd	nd
BENZO(B)FLUORANTHENE	ng/g	279	-	-	nd	nd	nd	nd
BENZO(K)FLUORANTHENE	ng/g	430	-	-	nd	nd	nd	nd
BENZO(E)PYRENE	ng/g	81.5	-	-	nd	nd	nd	nd
BENZO(A)PYRENE	ng/g	277	31.9	782	nd	nd	nd	nd
PERYLENE	ng/g	163	-	-	nd	nd	nd	nd
INDENO(1,2,3-CD)PYRENE	ng/g	367	-	-	nd	nd	nd	nd
DIBENZ(A,H)ANTHRACENE	ng/g	163	6.22	135	nd	nd	nd	nd
BENZO(G,H,I)PERYLENE	ng/g	580	-	-	nd	nd	nd	nd
NAPHTHALENE-D8	%	-	-	-	48	43	59	67
FLUORENE-D10	%	-	-	-	46	49	62	62
PYRENE-D10	%	-	-	-	48	51	67	63
D-PERYLENE	%	-	-	-	42	43	60	63

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; ng/g = nanograms per gram
2. CCME Guidelines = CCME Canadian Sediment Quality Guidelines for the Protection Of Aquatic Life, updated 2002 (http://www.ccme.ca/assets/pdf/sedqg_summary_table.pdf accessed January 8, 2009)
3. ISQG = Interim Freshwater Sediment Quality Guidelines (dry weight); PEL = Probable Effect Levels (dry weight)
4. ISQG guideline exceedances bolded; PEL guideline exceedances shaded

Table B.2 - Sediment Sampling Results - Polycyclic Aromatic Hydrocarbons (PAHs)

PARAMETER	Units	MDL	CCME Guidelines		NF03OE0043 (Dup)	NF03OE0044	NF03OE0045
			ISQG	PEL	22/Aug/2008	22/Aug/2008	21/Aug/2008
INDENE	ng/g	142	-	-	nd	nd	nd
1,2,3,4-TETRAHYDRONAPHTHALENE	ng/g	132	-	-	nd	nd	nd
NAPHTHALENE	ng/g	81.5	34.6	391	nd	nd	nd
2-METHYLNAPHTHALENE	ng/g	118	20.2	201	nd	nd	nd
1-METHYLNAPHTHALENE	ng/g	132	-	-	nd	nd	nd
2-CHLORONAPHTHALENE	ng/g	126	-	-	nd	nd	nd
ACENAPHTHYLENE	ng/g	136	5.87	128	nd	nd	nd
ACENAPHTHENE	ng/g	187	6.71	88.9	nd	nd	nd
FLUORENE	ng/g	174	21.2	144	nd	nd	nd
PHENANTHRENE	ng/g	163	41.9	515	nd	nd	nd
ANTHRACENE	ng/g	81.5	46.9	245	nd	nd	nd
FLUORANTHENE	ng/g	86.2	111	2355	nd	nd	nd
PYRENE	ng/g	94.2	53	875	nd	nd	nd
BENZO(A)ANTHRACENE	ng/g	81.5	31.7	385	nd	nd	nd
CHRYSENE	ng/g	81.5	57.1	862	nd	nd	nd
BENZO(B)FLUORANTHENE	ng/g	279	-	-	nd	nd	nd
BENZO(K)FLUORANTHENE	ng/g	430	-	-	nd	nd	nd
BENZO(E)PYRENE	ng/g	81.5	-	-	nd	nd	nd
BENZO(A)PYRENE	ng/g	277	31.9	782	nd	nd	nd
PERYLENE	ng/g	163	-	-	nd	nd	nd
INDENO(1,2,3-CD)PYRENE	ng/g	367	-	-	nd	nd	nd
DIBENZ(A,H)ANTHRACENE	ng/g	163	6.22	135	nd	nd	nd
BENZO(G,H,I)PERYLENE	ng/g	580	-	-	nd	nd	nd
NAPHTHALENE-D8	%	-	-	-	83	54	82
FLUORENE-D10	%	-	-	-	69	49	68
PYRENE-D10	%	-	-	-	66	51	67
D-PERYLENE	%	-	-	-	56	44	63

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; ng/g = nanograms per gram
2. CCME Guidelines = CCME Canadian Sediment Quality Guidelines for the Protection Of Aquatic Life, updated 2002 (http://www.ccme.ca/assets/pdf/sedqg_summary_table.pdf accessed January 8, 2009)
3. ISQG = Interim Freshwater Sediment Quality Guidelines (dry weight); PEL = Probable Effect Levels (dry weight)
4. ISQG guideline exceedances bolded; PEL guideline exceedances shaded

Table B.2 - Sediment Sampling Results - Polycyclic Aromatic Hydrocarbons (PAHs)

PARAMETER	Units	MDL	CCME Guidelines		NF03OE0046	NF03OE0047	NF03OE0048
			ISQG	PEL	21/Aug/2008	22/Aug/2008	21/Aug/2008
INDENE	ng/g	142	-	-	nd	nd	nd
1,2,3,4-TETRAHYDRONAPHTHALENE	ng/g	132	-	-	nd	nd	nd
NAPHTHALENE	ng/g	81.5	34.6	391	nd	nd	nd
2-METHYLNAPHTHALENE	ng/g	118	20.2	201	nd	nd	nd
1-METHYLNAPHTHALENE	ng/g	132	-	-	nd	nd	nd
2-CHLORONAPHTHALENE	ng/g	126	-	-	nd	nd	nd
ACENAPHTHYLENE	ng/g	136	5.87	128	nd	nd	nd
ACENAPHTHENE	ng/g	187	6.71	88.9	nd	nd	nd
FLUORENE	ng/g	174	21.2	144	nd	nd	nd
PHENANTHRENE	ng/g	163	41.9	515	nd	nd	nd
ANTHRACENE	ng/g	81.5	46.9	245	nd	nd	nd
FLUORANTHENE	ng/g	86.2	111	2355	nd	nd	nd
PYRENE	ng/g	94.2	53	875	nd	nd	nd
BENZO(A)ANTHRACENE	ng/g	81.5	31.7	385	nd	nd	nd
CHRYSENE	ng/g	81.5	57.1	862	nd	nd	nd
BENZO(B)FLUORANTHENE	ng/g	279	-	-	nd	nd	nd
BENZO(K)FLUORANTHENE	ng/g	430	-	-	nd	nd	nd
BENZO(E)PYRENE	ng/g	81.5	-	-	nd	nd	nd
BENZO(A)PYRENE	ng/g	277	31.9	782	nd	nd	nd
PERYLENE	ng/g	163	-	-	nd	nd	nd
INDENO(1,2,3-CD)PYRENE	ng/g	367	-	-	nd	nd	nd
DIBENZ(A,H)ANTHRACENE	ng/g	163	6.22	135	nd	nd	nd
BENZO(G,H,I)PERYLENE	ng/g	580	-	-	nd	nd	nd
NAPHTHALENE-D8	%	-	-	-	71	73	47
FLUORENE-D10	%	-	-	-	53	54	50
PYRENE-D10	%	-	-	-	18	54	57
D-PERYLENE	%	-	-	-	1	7	44

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; ng/g = nanograms per gram
2. CCME Guidelines = CCME Canadian Sediment Quality Guidelines for the Protection Of Aquatic Life, updated 2002 (http://www.ccme.ca/assets/pdf/sedqg_summary_table.pdf accessed January 8, 2009)
3. ISQG = Interim Freshwater Sediment Quality Guidelines (dry weight); PEL = Probable Effect Levels (dry weight)
4. ISQG guideline exceedances bolded; PEL guideline exceedances shaded

Table B.3 - Sediment Sampling Results - Polychlorinated Biphenyls (PCBs)

SAMPLE LOCATION	Units	MDL[5]	CCME Guidelines		Total PCBs (µg/kg)
			ISQG	PEL	
NF03OE0040	µg/kg	-	34.1	277	5.31
NF03OE0041	µg/kg	-	34.1	277	7.77
NF03OE0042	µg/kg	-	34.1	277	5.83
NF03OE0043	µg/kg	-	34.1	277	3.91
NF03OE0043 (Fdup)	µg/kg	-	34.1	277	2.45
NF03OE0044	µg/kg	-	34.1	277	4.44
NF03OE0045	µg/kg	-	34.1	277	4.61
NF03OE0046	µg/kg	-	34.1	277	3.82
NF03OE0047	µg/kg	-	34.1	277	2.75
NF03OE0048	µg/kg	-	34.1	277	3.03

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; µg/kg = micrograms per kilogram
2. CCME Guidelines = CCME Canadian Sediment Quality Guidelines for the Protection Of Aquatic Life, updated 2002 (http://www.ccme.ca/assets/pdf/sedqg_summary_table.pdf accessed January 8, 2009)
3. ISQG = Interim Freshwater Sediment Quality Guidelines (dry weight); PEL = Probable Effect Levels (dry weight)
4. ISQG guideline exceedances bolded; PEL guideline exceedances shaded
5. No method detection limit provided by laboratory.

Table B.4 - Sediment Sampling Results - Organochlorine (OC) Pesticides

PARAMETER	Units	MDL	CCME Guidelines		NF03OE0040	NF03OE0041	NF03OE0042	NF03OE0043	NF03OE0043 (Fdup)
			ISQG	PEL	21/Aug/2008	21/Aug/2008	22/Aug/2008	22/Aug/2008	22/Aug/2008
ALPHA-HCH	ng/g	1.66	-	-	nd	nd	nd	nd	nd
HEXACHLOROBENZENE	ng/g	0.8	-	-	nd	nd	nd	nd	nd
GAMMA-HCH	ng/g	1.3	-	-	nd	nd	nd	nd	nd
HEPTACHLOR	ng/g	1.83	-	-	nd	nd	nd	nd	nd
ALDRIN	ng/g	1.48	-	-	nd	nd	nd	nd	nd
HEPTACHLOR EPOXIDE	ng/g	1.56	0.6	2.74	nd	nd	nd	nd	nd
GAMMA (TRANS)-CHLORDANE	ng/g	1.89	-	-	nd	nd	nd	nd	nd
ALPHA-ENDOSULFAN	ng/g	2.45	-	-	nd	nd	nd	nd	nd
ALPHA (CIS)-CHLORDANE	ng/g	2	-	-	nd	nd	nd	nd	nd
DIELDRIN	ng/g	2.48	2.85	6.67	nd	nd	nd	nd	nd
ENDRIN	ng/g	4.06	2.67	62.4	nd	nd	nd	nd	nd
BETA-ENDOSULFAN	ng/g	4.65	-	-	nd	nd	nd	nd	nd
O,P,-DDD	ng/g	4.73	3.54[5]	8.51[5]	nd	nd	nd	nd	nd
P,P-DDD	ng/g	1.24	3.54[5]	8.51[5]	nd	nd	nd	nd	nd
O,P-DDT	ng/g	7.91	1.19[5]	4.77[5]	nd	nd	nd	nd	nd
P,P-DDT	ng/g	3.37	1.19[5]	4.77[5]	nd	nd	nd	nd	nd
O,P-DDE	ng/g	0.65	1.42[5]	6.75[5]	nd	nd	nd	nd	nd
P,P-DDE	ng/g	3.67	1.42[5]	6.75[5]	nd	nd	nd	nd	nd
P,P-METHOXYCHLOR	ng/g	24.6	-	-	nd	nd	nd	nd	nd
MIREX	ng/g	2.12	-	-	nd	nd	nd	nd	nd
PENTACHLOROBENZENE	ng/g	0.75	-	-	nd	nd	nd	nd	nd
PENTACHLOROANISOLE	ng/g	1.22	-	-	nd	nd	nd	nd	nd
BETA - HCH	ng/g	2.77	-	-	nd	nd	nd	nd	nd
CIS-NONACHLOR	ng/g	1.22	-	-	nd	nd	nd	nd	nd
OXYCHLORDANE	ng/g	3.67	-	-	nd	nd	nd	nd	nd
HEXACHLOROBUTADIENE	ng/g	0.65	-	-	nd	nd	nd	nd	nd
TRANS-NONACHLOR	ng/g	1.71	-	-	nd	nd	nd	nd	nd
DELTA-HCH	%	-	-	-	81	82	81	75	80
1,2,4,5-TETRABROMOBENZENE	%	-	-	-	84	86	82	77	83
ENDRIN KETONE	%	-	-	-	86	81	78	< 1	< 1

Notes:

1. OC = Organochlorine; MDL = method detection limit; nd = not detected at method detection limit; ng/g = nanograms per gram; Fdup = field duplicate
2. CCME Guidelines = CCME Canadian Sediment Quality Guidelines for the Protection Of Aquatic Life, updated 2002 (http://www.ccme.ca/assets/pdf/sedqg_summary_table.pdf accessed January 8, 2009)
3. ISQG = Interim Freshwater Sediment Quality Guidelines (dry weight); PEL = Probable Effect Levels (dry weight)
4. ISQG guideline exceedances bolded; PEL guideline exceedances shaded
5. Sum of p,p' and o,p' isomers.

Table B.4 - Sediment Sampling Results - Organochlorine (OC) Pesticides

PARAMETER	Units	MDL	CCME Guidelines		NF03OE0044	NF03OE0045	NF03OE0046	NF03OE0047	NF03OE0048
			ISQG	PEL	22/Aug/2008	21/Aug/2008	21/Aug/2008	22/Aug/2008	21/Aug/2008
ALPHA-HCH	ng/g	1.66	-	-	nd	nd	nd	nd	nd
HEXACHLOROBENZENE	ng/g	0.8	-	-	nd	nd	nd	nd	nd
GAMMA-HCH	ng/g	1.3	-	-	nd	nd	nd	nd	nd
HEPTACHLOR	ng/g	1.83	-	-	nd	nd	nd	nd	nd
ALDRIN	ng/g	1.48	-	-	nd	nd	nd	nd	nd
HEPTACHLOR EPOXIDE	ng/g	1.56	0.6	2.74	nd	nd	nd	nd	nd
GAMMA (TRANS)-CHLORDANE	ng/g	1.89	-	-	nd	nd	nd	nd	nd
ALPHA-ENDOSULFAN	ng/g	2.45	-	-	nd	nd	nd	nd	nd
ALPHA (CIS)-CHLORDANE	ng/g	2	-	-	nd	nd	nd	nd	nd
DIELDRIN	ng/g	2.48	2.85	6.67	nd	nd	nd	nd	nd
ENDRIN	ng/g	4.06	2.67	62.4	nd	nd	nd	nd	nd
BETA-ENDOSULFAN	ng/g	4.65	-	-	nd	nd	nd	nd	nd
O,P,-DDD	ng/g	4.73	3.54[5]	8.51[5]	nd	nd	nd	nd	nd
P,P-DDD	ng/g	1.24	3.54[5]	8.51[5]	nd	nd	nd	nd	nd
O,P-DDT	ng/g	7.91	1.19[5]	4.77[5]	nd	nd	nd	nd	nd
P,P-DDT	ng/g	3.37	1.19[5]	4.77[5]	nd	nd	nd	nd	nd
O,P-DDE	ng/g	0.65	1.42[5]	6.75[5]	nd	nd	nd	nd	nd
P,P-DDE	ng/g	3.67	1.42[5]	6.75[5]	nd	nd	nd	nd	nd
P,P-METHOXYCHLOR	ng/g	24.6	-	-	nd	nd	nd	nd	nd
MIREX	ng/g	2.12	-	-	nd	nd	nd	nd	nd
PENTACHLOROBENZENE	ng/g	0.75	-	-	nd	nd	nd	nd	nd
PENTACHLOROANISOLE	ng/g	1.22	-	-	nd	nd	nd	nd	nd
BETA - HCH	ng/g	2.77	-	-	nd	nd	nd	nd	nd
CIS-NONACHLOR	ng/g	1.22	-	-	nd	nd	nd	nd	nd
OXYCHLORDANE	ng/g	3.67	-	-	nd	nd	nd	nd	nd
HEXACHLOROBUTADIENE	ng/g	0.65	-	-	nd	nd	nd	nd	nd
TRANS-NONACHLOR	ng/g	1.71	-	-	nd	nd	nd	nd	nd
DELTA-HCH	%	-	-	-	75	75	71	73	75
1,2,4,5-TETRABROMOBENZENE	%	-	-	-	76	82	77	80	73
ENDRIN KETONE	%	-	-	-	78	75	72	76	81

Notes:

1. OC = Organochlorine; MDL = method detection limit; nd = not detected at method detection limit; ng/g = nanograms per gram; Fdup = field duplicate

2. CCME Guidelines = CCME Canadian Sediment Quality Guidelines for the Protection Of Aquatic Life, updated 2002 (http://www.ccme.ca/assets/pdf/sedqg_summary_table.pdf accessed January 8, 2009)

3. ISQG = Interim Freshwater Sediment Quality Guidelines (dry weight); PEL = Probable Effect Levels (dry weight)

4. ISQG guideline exceedances bolded; PEL guideline exceedances shaded

5. Sum of p,p' and o,p' isomers.

Appendix C

Biota Chemistry Results

Table C.1 - Biota Sampling Results - Metals

PARAMETER	Units	MDL	Guidelines		NF03OE0049	NF03OE0049	NF03OE0049	NF03OE0049
			Health Canada	CCME - TRG	2008001725	2008001726	2008001727	2008001728
					23/Aug/2008	23/Aug/2008	23/Aug/2008	23/Aug/2008
MOISTURE	**%**	**-**	**-**	**-**	78.4	75.7	79.2	79.4
ALUMINUM	**mg/kg**		**-**	**-**	520	503	1122	861
ANTIMONY	**mg/kg**	**5**	**-**	**-**	nd	nd	nd	nd
ARSENIC	**mg/kg**	**2**	**-**	**-**	nd	nd	nd	nd
BARIUM	**mg/kg**		**-**	**-**	16	13	21	23
BERYLLIUM	**mg/kg**		**-**	**-**	nd	nd	nd	nd
CADMIUM	**mg/kg**	**1**	**-**	**-**	nd	nd	nd	nd
CHROMIUM	**mg/kg**	**5**	**-**	**-**	nd	nd	11	7
COBALT	**mg/kg**		**-**	**-**	1	1	1	1
COPPER	**mg/kg**		**-**	**-**	28	33	79	59
IRON	**mg/kg**		**-**	**-**	959	1014	2051	1518
LEAD	**mg/kg**	**3**	**-**	**-**	nd	nd	nd	nd
MANGANESE	**mg/kg**		**-**	**-**	34	26	44	45
TOTAL MERCURY	**mg/kg**		**0.5[2]**	**0.033[3]**	**0.062**	0.023	0.016	**0.053**
MOLYBDENUM	**mg/kg**	**1**	**-**	**-**	nd	nd	1	nd
NICKEL	**mg/kg**	**3**	**-**	**-**	nd	nd	nd	nd
SELENIUM	**mg/kg**	**5**	**-**	**-**	nd	nd	nd	nd
SILVER	**mg/kg**	**1**	**-**	**-**	nd	nd	nd	nd
STRONTIUM	**mg/kg**		**-**	**-**	59	46	44	47
THALLIUM	**mg/kg**	**3**	**-**	**-**	nd	nd	nd	nd
TIN	**mg/kg**		**-**	**-**	3	3	8	7
TITANIUM	**mg/kg**		**-**	**-**	61	59	123	95
VANADIUM	**mg/kg**		**-**	**-**	2	3	4	3
ZINC	**mg/kg**	**100**	**-**	**-**	nd	nd	nd	nd

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; mg/kg = milligrams per kilogram (wet weight)
2. Health Canada limit for mercury in fish for commercial sale (HC, 2007)
3. CCME-TRG = CCME Canadian Tissue Residue Guidelines for the Protection of Wildlife Consumers and Aquatic Biota, updated 2001 (http://www.ccme.ca/assets/pdf/trg_summary_table.pdf accessed December 7, 2009)
4. CCME tissue residue guideline for methylmercury is presented here. Comparison with guideline is used since majority of mercury in fish is in the methylmercury form (Rodgers, 1994)

Table C.2 - Biota Sampling Results - Polycyclic Aromatic Hydrocarbons (PAHs)

PARAMETER	Units	MDL	NF03OE0049 2008001725 23/Aug/2008	NF03OE0049 2008001726 23/Aug/2008	NF03OE0049 2008001727 23/Aug/2008	NF03OE0049 2008001728 23/Aug/2008	Blank 2008001729 16/Oct/2008
INDENE	ng/g	68.1	nd	nd	nd	nd	nd
1,2,3,4-TETRAHYDRONAPHTHALENE	ng/g	179	nd	nd	nd	nd	nd
NAPHTHALENE	ng/g	50	nd	nd	nd	nd	nd
2-METHYLNAPHTHALENE	ng/g	87.5	nd	nd	nd	nd	nd
1-METHYLNAPHTHALENE	ng/g	61.4	nd	nd	nd	nd	nd
2-CHLORONAPHTHALENE	ng/g	40.9	nd	nd	nd	nd	nd
ACENAPHTHYLENE	ng/g	48.3	nd	nd	nd	nd	nd
ACENAPHTHENE	ng/g	52.6	nd	nd	nd	nd	nd
FLUORENE	ng/g	63	nd	nd	nd	nd	nd
PHENANTHRENE	ng/g	44.4	nd	nd	nd	nd	nd
ANTHRACENE	ng/g	50	nd	nd	nd	nd	nd
FLUORANTHENE	ng/g	40	nd	nd	nd	nd	nd
PYRENE	ng/g	37.2	nd	nd	nd	nd	nd
BENZO(A)ANTHRACENE	ng/g	50	nd	nd	nd	nd	nd
CHRYSENE	ng/g	50	nd	nd	nd	nd	nd
BENZO(B)FLUORANTHENE	ng/g	193	nd	nd	nd	nd	nd
BENZO(K)FLUORANTHENE	ng/g	161	nd	nd	nd	nd	nd
BENZO(E)PYRENE	ng/g	50	nd	nd	nd	nd	nd
BENZO(A)PYRENE	ng/g	176	nd	nd	nd	nd	nd
PERYLENE	ng/g	50	nd	nd	nd	nd	nd
INDENO(1,2,3-CD)PYRENE	ng/g	254	nd	nd	nd	nd	nd
DIBENZ(A,H)ANTHRACENE	ng/g	50	nd	nd	nd	nd	nd
BENZO(G,H,I)PERYLENE	ng/g	229	nd	nd	nd	nd	nd
NAPHTHALENE-D8	%	-	60	65	64	57	64
FLUORENE-D	%	-	69	74	82	63	68
PYRENE-D10	%	-	98	99	109	90	101
D-PERYLENE	%	-	38	30	45	21	38

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; ng/g = nanograms per gram

Table C.3 - Biota Sampling Results - Polychlorinated Biphenyls (PCBs)

PARAMETER	Units	MDL	CCME Guidelines	NF03OE0049 2008001725 23/Aug/2008	NF03OE0049 2008001726 23/Aug/2008	NF03OE0049 2008001727 23/Aug/2008	NF03OE0049 2008001728 23/Aug/2008	LAB BLANK 200808039 16/Oct/2008
Total PCBs	**ng/g**	**-**	**-**	22.1	80.2	74.0	21.6	12.9
PCB 30 - surrogate	**%**	**-**	**-**	132	131	115	118	125
PCB 204 - surrogate	**%**	**-**	**-**	135	141	124	128	132
Dioxin Toxic Equivalents - Mammalian	**ng TEQ/kg**	**-**	**0.79**	**9.0**	**42.5**	**36.7**	**8.9**	**2.1**
Dioxin Toxic Equivalents - Avian	**ng TEQ/kg**	**-**	**2.4**	**83.3**	**311.5**	**282.2**	**79.0**	**52.0**

Notes

1. MDL = method detection limit; ng/g = nanograms per gram; ng TEQ/kg = nanograms of toxic equivalents per kilogram

2. TEQ - refers to dioxin toxic equivalents using toxic equivalency factors (TEFs) for PCBs for mammal or birds developed by the World Health Organization in 1998 (CCME, 2001)

3. CCME Guidelines = CCME Canadian Tissue Residue Guidelines for the Protection of Wildlife Consumers and Aquatic Biota, updated 2001 (http://www.ccme.ca/assets/pdf/trg_summary_table.pdf accessed December 7, 2009). Bolding indicates exceedance of guideline (see discussion of exceedances in Section 3.3.2.2)

Table C.4 - Biota Sampling Results - Organochlorine (OC) Pesticides

PARAMETER	Units	MDL	CCME Guidelines	NF03OE0049 2008001725 23/Aug/2008	NF03OE0049 2008001726 23/Aug/2008	NF03OE0049 2008001727 23/Aug/2008	NF03OE0049 2008001728 23/Aug/2008	LAB BLANK 200808039 16/Oct/2008
ALPHA -HCH	ng/g	0.07	-	nd	nd	nd	nd	nd
HEXACHLOROBENZENE	ng/g	0.15	-	0.19	0.26	0.19	nd	0.30
1,2,4,5-TETRABROMOBENZENE	%	-	-	97	105	89	91	101
GAMMA-HCH	ng/g	0.06	-	0.25	0.62	0.21	0.09	nd
DELTA-HCH	%	-	-	93	93	102	95	95
HEPTACHLOR	ng/g	0.13	-	nd	nd	nd	nd	nd
ALDRIN	ng/g	0.26	-	nd	nd	nd	nd	nd
HEPTACHLOR EPOXIDE	ng/g	0.15	-	nd	nd	nd	nd	nd
GAMMA (TRANS)-CHLORDANE	ng/g	0.15	-	nd	0.38	0.60	nd	nd
ALPHA-ENDOSULFAN	ng/g	0.26	-	nd	nd	nd	nd	nd
ALPHA (CIS)-CHLORDANE	ng/g	0.19	-	nd	0.38	0.66	nd	nd
DIELDRIN	ng/g	0.2	-	0.21	0.34	0.23	nd	nd
ENDRIN	ng/g	0.52	-	nd	nd	nd	nd	nd
BETA-ENDOSULFAN	ng/g	0.22	-	nd	nd	nd	nd	nd
O,P-DDT	ng/g	0.41	14[3]	nd	0.94	**1.72**	nd	nd
P,P-DDT	ng/g	0.29	14[3]	0.90	5.31	**13.0**	0.89	nd
O,P,-DDD	ng/g	0.22	-	0.87	1.92	2.61	0.55	nd
P,P-DDD	ng/g	0.32		4.71	11.1	17.5	2.77	nd
O,P-DDE	ng/g	0.26	-	nd	0.32	0.37	nd	nd
P,P-DDE	ng/g	0.87	-	4.06	11.0	11.3	2.42	1.05
ENDRIN KETONE	%	-	-	<1	< 1	< 1	< 1	< 1
P,P-METHOXYCHLOR	ng/g	2.33	-	nd	nd	nd	nd	nd
MIREX	ng/g	0.57	-	nd	nd	nd	nd	nd
PENTACHLOROBENZENE	ng/g	0.16	-	nd	nd	nd	nd	nd
HEXACHLOROBUTADIENE	ng/g	0.12	-	nd	nd	nd	nd	nd
BETA - HCH	ng/g	0.16	-	nd	nd	nd	nd	nd
PENTACHLOROANISOLE	ng/g	0.06	-	0.10	0.11	0.06	nd	0.15
OXYCHLORDANE	ng/g	0.2	-	nd	nd	nd	nd	nd
TRANS-NONACHLOR	ng/g	0.14	-	nd	0.38	0.58	nd	nd
CIS-NONACHLOR	ng/g	0.12	-	nd	0.18	0.26	nd	nd

Notes:

1. MDL = method detection limit; nd = not detected at method detection limit; ng/g = nanograms per gram

2. CCME Guidelines = CCME Canadian Tissue Residue Guidelines for the Protection of Wildlife Consumers and Aquatic Biota, updated 2001 (http://www.ccme.ca/assets/pdf/trg_summary_table.pdf accessed December 7, 2009)

3. Sum of p,p' and o,p' isomers.

4. Guideline exceedances bolded.