Environment Canada Environnement Canada

Water Science and Technology Directorate

Direction générale des sciences et de la technologie, eau

Benthic Conditions in the St. Marys River from 2009 to 2010 and an Overview from 2002 to 2010

Danielle Milani

WSTD Contribution No. 12-093

Canada

Benthic Conditions in the St. Marys River from 2009 to 2010 and an Overview from 2002 to 2010

May 30, 2012

Environment Canada
Water Science and Technology Directorate
867 Lakeshore Road, Burlington, Ontario L7R 4A6

Danielle Milani

WSTD Contribution No. 12-093

EXECUTIVE SUMMARY

In 2009 to 2010, 22 stations were sampled in the St. Marys River focusing on East Bellevue Marine Park (EBMP) and Lake George Channel (LGC), two potentially problematic areas identified in previous studies. Increasing sampling station coverage in both EBMP and LGC provided assistance in developing a sediment management strategy for the St. Marys River. Data were collected on the benthic invertebrate community structure, functional responses of benthic invertebrates using laboratory toxicity tests, and the physical and chemical attributes of the sediment and overlying water. Conditions at test sites were compared with those at Great Lakes reference sites using multivariate techniques. Relationships between toxicity and contaminant concentrations were also evaluated by regression analysis. Data were applied to the Canada-Ontario decision-making framework for contaminated sediment to determine environmental risk. This report also includes an overview of previous studies conducted in the river from 2002 to 2010, including Bellevue Marine Park, providing a comprehensive picture of conditions in the depositional areas of the river.

Sediments in EBMP and the lower half of LGC consisted mainly of fines (particle size ≤ 63 um). Sediment nutrient and metal levels in EBMP and LGC were consistent with previous studies. TOC in 2009/2010 ranged from 3.0 to 8.0% (mean 6.4%) in EBMP and from 0.6 to 5.5% (mean 4.4%) in LGC and overall was elevated from BMP to LGC (with the exception of sites in the upper part of LGC) compared to upstream and Great Lakes reference. Several metals (from 1 to 9 metals) exceeded Sediment Quality Guidelines Lowest Effect Levels in EBMP and LGC while exceedences of the Severe Effect Level were limited mainly to manganese and iron. Total PAHs in EBMP ranged from 18.6 to 38.5 mg/kg (median 23.4 mg/kg) and from 0.5 to 25.4 mg/kg (median 15.0 mg/kg) in LGC. Overall, all areas were elevated in PAHs compared to the upstream reference locations, where a maximum of 0.4 mg/kg was found. Where there was concurrent data for parent and alkylated PAHs (2010 data), the parent PAH compounds dominated, consisting of approximately 60% of the total PAHs. Alkylated PAHs (the 16 compounds recommended for measurement by the USEPA) ranged from 12.7 to 19.6 mg/kg and 7.8 to 14.3 mg/kg in EBMP and LGC, respectively, and the C1-C4 phenanthrenes/anthracenes were the prevalent homologs. Examination of PAH patterns and ratios suggested the PAH source to be combustion-derived. Total petroleum hydrocarbons were similarly elevated in all areas, with average concentrations of 2400, 2326 and 2389 mg/kg for BMP, EBMP and LGC, respectively. Oil and grease was quite elevated in EBMP compared to LGC and BMP, with average concentrations of 3834 mg/kg, 2107 and 470 mg/kg, respectively.

There was no strong evidence of benthic community impairment in the 2009-2010 EBMP and LGC samples, which were categorized as either equivalent to reference or possibly different than reference. However, there was benthic impairment in EBMP and LGC evident from previous studies. Overall, the benthic composition in EBMP and LGC was most dissimilar to the Great Lakes and upstream reference sites, with increased abundances of oligochaete worms and chironomids and lower taxon diversity. Taxa such as mites, dipterans (other than chironomids) annelids (other than tubificids and naidids) and asellids were lower in EBMP and LGC compared to reference sites. Benthic communities in BMP were improved over EBMP and LGC and were more similar to reference.

Almost half the 2009-2010 sites were severely toxic or toxic and about a third were potentially toxic. Effects on the midge *Chironomus* (acute) and mayfly *Hexagenia* (chronic) were evident and mostly restricted to EBMP, while effects on the amphipod *Hyalella* (acute and chronic) and the worm *Tubifex* (chronic) were evident in EBMP as well as LGC. Overall, toxicity was more prevalent in EBMP than in LGC or BMP. Correlation of toxicological response to sediment contaminants, nutrients and particle size was weak ($r^2 \leq 0.16$). Additional regressions showed relationships between parent and alkylated PAHs and *Tubifex* reproduction (reduced cocoon hatching and young production) and *Hexagenia* growth; however, correlations were fairly weak ($r^2 \leq 0.23$). Toxic units calculated for PAHs indicated that it was unlikely that the adverse effects seen at some sites were from PAHs. Previous examination of toxicity-contaminant relationships showed varied results between studies and no contaminant could be identified as the singular cause of toxicity.

Application of the decision-making framework from 2002 to 2010 indicated that management actions were required at seven sites in EBMP and two sites in LGC. Sufficient biological data exist to develop a sediment management plan for St. Marys River and further benthic invertebrate sampling and toxicity testing are not required at this time.

RÉSUMÉ

En 2009 et 2010, 22 stations ont été échantillonnées dans la rivière St. Marys, en particulier à l'est du parc marin Bellevue et dans le chenal du lac George, deux secteurs potentiellement problématiques selon des études précédentes. L'échantillonnage accru des stations de l'est du parc marin Bellevue et du chenal du lac George a contribué à l'élaboration d'une stratégie de gestion des sédiments pour la rivière St. Marys. Des données ont été recueillies sur la structure de la communauté d'invertébrés benthiques, sur les réponses fonctionnelles de ces invertébrés dans le cadre de tests de toxicité en laboratoire ainsi que sur les caractéristiques physiques et chimiques des sédiments et de l'eau sus-jacente. Les conditions aux sites d'essai ont été comparées à celles des sites de référence des Grands Lacs au moyen de techniques à plusieurs variables. Les liens entre la toxicité et les concentrations de contaminants ont également été évalués à l'aide d'une analyse de régression. Les données ont été appliquées au cadre décisionnel relatif à l'Accord Canada-Ontario concernant les sédiments contaminés afin de déterminer les risques environnementaux. Ce rapport comporte également un survol des précédentes études menées dans la rivière de 2002 à 2010, y compris le parc marin de Bellevue, afin de présenter un portrait complet des conditions dans les aires de sédimentation de la rivière.

Les sédiments à l'est du parc marin Bellevue et dans la moitié inférieure du chenal du lac George étaient principalement des particules fines (taille ≤ 63 µm). Les concentrations de nutriments et de métaux à l'est du parc marin Bellevue et dans le chenal du lac George correspondaient à celles des études précédentes. Les concentrations de carbone organique total en 2009 et 2010 variaient de 3,0 à 8,0 % (moyenne de 6,4 %) à l'est du parc marin Bellevue et de 0,6 à 5,5 % (moyenne de 4,4 %) dans le chenal du lac George. Dans l'ensemble, elles étaient plus élevées dans le parc marin Bellevue et le chenal du lac George (à l'exception des sites dans la partie supérieure du chenal) qu'aux sites de référence en amont ou dans les Grands Lacs. Plusieurs métaux (de 1 à 9 métaux) dépassaient les concentrations minimales avec effet stipulées dans les Recommandations pour la qualité des sédiments pour l'est du parc marin Bellevue et le chenal du lac George, mais les dépassements des concentrations avec effets graves étaient principalement limités au manganèse et au fer. Les concentrations de HAP totaux variaient de 18,6 à 38,5 mg/kg (valeur médiane de 23,4 mg/kg) à l'est du parc marin Bellevue et de 0,5 à 25,4 mg/kg (valeur médiane de 15,0 mg/kg) dans le chenal du lac George. Dans l'ensemble, tous les secteurs présentaient des concentrations élevées de HAP par rapport aux sites de référence en amont, où la concentration maximale mesurée était de 0,4 mg/kg). Aux endroits où il y avait des données pour les HAP apparentés et alkylés (données de 2010), les composés de HAP apparentés étaient les plus présents, soit environ 60 % des HAP

totaux. Les concentrations de HAP alkylés (les 16 composés dont la mesure est recommandée par l'Environmental Protection Agency des États-Unis) variaient de 12,7 à 19,6 mg/kg et de 7,8 à 14,3 mg/kg à l'est du parc marin Bellevue et dans le chenal du lac George, respectivement. Les phénanthrènes et les anthracènes de 1 à 4 atomes de carbone étaient les homologues les plus fréquents. L'examen des tendances et des ratios concernant les HAP semble indiquer que la source des HAP est la combustion. Les hydrocarbures pétroliers totaux présentaient des concentrations élevées similaires dans tous les secteurs, soit 2 400, 2 326 et 2 389 mg/kg en moyenne pour le parc marin Bellevue, l'est du parc marin Bellevue et le chenal du lac George, respectivement. Les concentrations d'huiles et de graisses étaient assez élevées à l'est du parc marin Bellevue comparativement au chenal du lac George et au parc marin Bellevue, soit 3 834, 2 107 et 470 mg/kg en moyenne, respectivement.

Les échantillons de 2009 et 2010 prélevés à l'est du parc marin Bellevue et dans le chenal du lac George n'indiquaient pas clairement d'effets nocifs sur la communauté benthique. Ces échantillons ont été classés en deux catégories, soit équivalents aux sites de référence ou potentiellement différents des sites de référence. Cependant, des études précédentes ont fait état d'effets nocifs pour cette communauté à l'est du parc marin Bellevue et dans le chenal du lac George. Dans l'ensemble, la composition benthique à l'est du parc marin Bellevue et dans le chenal du lac George était très différente de celle des sites de référence en amont et dans les Grands Lacs. Les vers oligochètes ainsi que les chironomidés étaient plus abondants, et la diversité taxonomique était plus faible. Les taxons comme les acariens, les diptères (autres que les chironomidés), les annélides (autres que les tubificidés et les naididés) et les isopodes Asellidae étaient moins nombreux à l'est du parc marin Bellevue et dans le chenal du lac George qu'aux sites de référence. Les communautés benthiques dans le parc marin Bellevue étaient en meilleure état qu'à l'est du parc marin Bellevue et que dans le chenal du lac George, et ressemblaient davantage à celles des sites de référence.

Presque la moitié des sites de 2009 et 2010 étaient très toxiques ou toxiques, et environ un tiers étaient potentiellement toxiques. Les effets sur le moucheron *Chironomus* (aigus) et l'éphémère commune *Hexagenia* (chronique) étaient manifestes et ont principalement été observés à l'est du parc marin Bellevue, tandis que les effets sur l'amphipode *Hyalella* (aigus et chronique) et le ver *Tubifex* (chroniques) étaient manifestes à l'est du parc marin Bellevue et dans le chenal du lac George. Dans l'ensemble, la toxicité était plus répandue à l'est du parc marin Bellevue que dans le chenal du lac George ou le parc marin Bellevue. La corrélation entre, d'une part, la réponse toxicologique et, d'autre part, les contaminants et les nutriments sédimentaires ainsi que la taille des particules était faible ($r^2 \leq 0,16$). Des régressions additionnelles ont montré un lien entre la présence de HAP apparentés et alkylés et la reproduction de *Tubifex* (réduction de l'éclosion des cocons et de la production de petits) ainsi que la croissance de *Hexagenia*. Cependant, les corrélations étaient assez faibles ($r2 \leq 0,23$). Les unités toxiques calculées pour les HAP montrent qu'il est peu probable que les effets nocifs observés à certains sites soient causés par les HAP. Un examen précédent des relations entre la toxicité et les contaminants a montré des résultats variables selon les études, et aucun contaminant n'a pu être établi comme étant la seule cause de la toxicité.

La mise en application du cadre décisionnel de 2002 à 2010 a montré que des mesures de gestion étaient nécessaires pour sept sites situés à l'est du parc marin Bellevue et deux sites du chenal du lac George. Les données biologiques sont suffisantes pour élaborer un plan de gestion des sédiments de la rivière St. Marys. Il n'est donc pas nécessaire de procéder à d'autres échantillonnages des invertébrés benthiques et essais de toxicité pour le moment.

ACKNOWLEDGEMENTS

The field and/or technical support of Sherri Thompson, Jennifer Webber and Jesse Baillargeon (AEIRD), Ross Neureuther and Cory Treen (EOSLD) and the Canadian Coast Guard are acknowledged.

Thanks to Drs. Agnes Richards of Environment Canada and Paula Antunes of the Sault St. Marie Innovation Center for their review of this report.

Funding for this project was provided by the Great Lakes Action Plan 4.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS, ACRONYMS AND SYMBOLS

ANT	Anthracene
AOC	Area of Concern
BEAST	Benthic Assessment of Sediment
BTEX	benzene, toluene, ethylbenzene and xylene
CCME	Canadian Council of Ministers of the Environment
CDGPS	Canada-wide differential global positioning system
CV	coefficient of variation
DL	detection limit
dw	dry weight
EC	Environment Canada
FL	fluoranthene
GL	Great Lakes
HMDS	hybrid multidimensional scaling
LEL	lowest effect level
LKSD	lake sediment standard
max	maximum
min	minimum
MOE	Ministry of the Environment (Ontario)
PAH	polycyclic aromatic hydrocarbon
PAH_{par}	parent PAH compounds
PAH_{34}	parent + 16 alkylated homologues
PCB	polychlorinated biphenyl
PEL	probable effect level
PHE	phenanthrene
PHC	petroleum hydrocarbon
PLS	partial least square
PY	pyrene
QA/QC	quality assurance/quality control
RL	reporting limit
RPD	relative percent difference
SEL	severe effect level
SQG	sediment quality guideline
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TP	total phosphorus
TU	toxic unit
wt	weight

1 INTRODUCTION

1.1 Previous Studies: 2002 to 2008

Environment Canada has conducted several assessments of sediment quality for the St. Marys River between 2002 and 2008. In 2002, sampling of surficial sediment for physico-chemical characteristics, benthic invertebrate community composition and toxicity testing occurred at 31 sites from Izaak Walton Bay (upstream reference) to Little Lake George (Fig. 1a). Based on these analyses, there was no strong evidence of benthic community impairment, with the exception of the Algoma slip (Milani and Grapentine 2006). Toxicity, however, was evident in sediments collected in the area adjacent to Bellevue Marine Park (BMP), a ~2.5 km stretch of river between the government dock and Topsail Island (Fig. 1b), and in Lake George Channel (LGC) (Fig. 1d). For these locations, the data obtained showed reduced survival of the midge *Chironomus* and reduced growth of the mayfly *Hexagenia* (Milani and Grapentine 2006).

In 2006, sampling shifted focus to BMP, increasing the spatial coverage to further characterize benthic conditions in this area, since only 6 sites were sampled at BMP in 2002. Additional sampling occurred in LGC (near Partridge Point) as well as in an area just downstream of BMP, where significant depositional areas were identified by acoustic mapping and classification of bottom sediments (Biberhofer, unpublished) (Figs. 1b, 1c). For reporting purposes, the area just downstream or east of BMP, which extends from east of Topsail Island to approximately 1 km downstream, is herein referred to as East Bellevue Marine Park (EBMP) (Fig. 1c). For these sites, the results demonstrated that sediment in BMP was at most mildly toxic, which was inconsistent with the 2002 results in a few cases (Milani and Grapentine 2009), while the sediment in EBMP and LGC was severely toxic. Application of the *Canada-Ontario Decision Making Framework for Assessment of Great Lakes Contaminated Sediment* (EC/MOE 2007) for the 2002 and 2006 sites at BMP indicated *no further actions needed* (2006 sites) or *determine reason(s) for sediment toxicity* (2002 sites). In EBMP, *management actions required or determine reason(s) for toxicity and benthos alteration* were indicated at one site each. In LGC, *determine reason(s) for sediment toxicity* and/or *determine reason(s) for benthos alteration* were indicated at most sites.

In 2008, increased sampling coverage was required where information on benthic conditions were limited or lacking in EBMP (only 2 sites were sampled in 2006) and in LGC, where elevated concentrations of petroleum hydrocarbons were found at surface and at depth (Burniston 2007). Fifteen sites were sampled, 11 of which were in EBMP and the other 4 in LGC). Results showed that benthic communities were *equivalent to* or *possibly different from* reference, with differences associated primarily with increased abundances of oligochaete worms and chironomids. Half of the sites in EBMP had diverse communities while the other half displayed low taxon diversity. Severe toxicity was observed at two sites and minor toxicity at several other sites. *Management actions* were indicated at two sites: one in EBMP and the other in LGC. Remaining sites indicated *no further action needed* (5 sites), *determine reason(s) for sediment toxicity* (6 sites), and *determine reason(s) for benthos alteration* (2 sites). Sampling stations in EBMP (in 2008) were about 100 to 200 m apart, and while these provided a good indication of problematic locations within EBMP, further spatial refinement of biological conditions was recommended in targeted areas in EBMP and LGC to assist in the formulation of a sediment management strategy for the river.

1.2 Current Studies: 2009 and 2010

In 2009 and 2010, a total of 26 sites were sampled (13 in EBMP, 9 in LGC and 4 upstream), for the purpose of targeting the potentially problematic areas identified in the previous studies. The upstream sites provided recent information on reference conditions in the river itself. Results from 2009 indicated that oil and grease concentrations in EBMP were up to an order of magnitude higher than those reported in the same area in 2008 where concentrations ranged from 300 to 1300 mg/kg in 2008 (Milani and Grapentine 2010) and from 2340 to 14000 mg/kg in 2009. This coincided with a change in methodology of oil and grease determination by the laboratory performing the analysis. To address this discrepancy in concentration between sampling years, split samples were taken in 2010 and sent to three separate labs for analysis. In an attempt to identify causative agent(s) of toxicity, oil and grease was normalized to volume, which has been shown to correlate well with toxicity in other studies (Mount et al. 2009). In addition, alkylated PAHs, previously unmeasured in the sediment, were analyzed in 2010 samples. Alkylated PAH compounds have known toxicities to the aquatic life (Rhodes et al. 2005).

The objectives of the 2009 to 2010 studies were to:

1. Increase sampling coverage in EBMP and LGC in targeted areas identified as being potentially problematic from previous studies;
2. Compare biological conditions at sample collection sites with reference locations;
3. Apply the COA decision-making framework to determine whether sediments pose an environmental risk;
4. Confirm oil and grease concentrations by split samples sent to separate laboratories because the laboratory methodology has changed;

5. Examine toxicity-contaminant relationships with oil and grease concentrations normalized to volume as well as examine the contribution of as the alkylated PAHs;
6. Provide an overview of environmental risk posed by contaminated sediment for 2002 to 2010 sites to assist in developing the sediment management plan for the river.

2 METHODS

2.1 Sample Collection

In 2009, 12 sites were sampled October 4-6:

- Eight sites in EBMP (Fig. 1c)
- Four sites in LGC (Fig. 1d)

In 2010, 14 sites were sampled October 26-29:

- Three sites in EBMP (Fig. 1b), positioned in areas of soft deposits in southern part of the area below where *management actions* was indicated (Fig. 1b)
- Five sites in LGC positioned around those where *management actions* were indicated from the 2006 and 2008 surveys (DBCR1, EC39 indicated mgt actions in 2008) and preliminary 2009 results additional targeted sampling (Fig. 1d)
- Four upstream reference sites (Fig. 1a). Due to difficulties in finding suitable reference locations, sampling new (previously unsampled) sites was not possible; therefore, one new site was sampled and three sites from the 2002 study were resampled
- Two previously sampled sites in EBMP were resampled for confirmation of oil and grease concentrations

Sites were positioned using a CDGPS-enabled GPS receiver resulting in 1 to 5 m level accuracy. Prior to sediment collections, site depth was recorded using a depth sounder and temperature, conductivity, pH and dissolved oxygen were measured in the water column approximately 0.5 m above the bottom using YSI meters. Water samples were collected with a van Dorn sampler 0.5 m above the sediments and tested for alkalinity, total phosphorus (preserved with 1 mL of 30% sulphuric acid), total Kjeldahl nitrogen, and total ammonia. A 40 cm × 40 cm mini-box corer was used to obtain the benthic community and sediment chemistry samples. Invertebrates were subsampled from the mini-box corer using 10 cm length × 6.5 cm diameter acrylic tubes. Sediment in the tubes was sieved through a 250-μm mesh screen and the residue preserved initially with 10% formalin; after a minimum of 72 hours, samples were rinsed and stored in 70% ethanol. The remaining top 10 cm of sediment from the mini-box core was removed, homogenized in a Pyrex dish, and allocated to containers for chemical and physical analyses of the sediment. In 2010, two sites (EC31, EC64) in EBMP were resampled to compare oil and grease concentrations to previous years. However, site EC31 was positioned approximately 30 m from its original location and was therefore not considered to be the same site. Five mini-Ponar grab samples were collected per site for the laboratory toxicity tests (approximately 2 L sediment per replicate). Each of the five sediment grab samples was placed in separate plastic bag, sealed, and stored in a 10-L bucket. Water and sediment samples were stored at 4°C with the exception of the organic contaminant samples, which were frozen (-20°C). Site positions, depth and sediment descriptions are provided in Table 1 and environmental variables measured at each site provided in Table 2.

2.2 Sample Analysis

Overlying water analyses (alkalinity, total phosphorus, nitrate + nitrite-N, ammonia-N and total Kjeldahl N) were performed by EC's National Laboratory for Environmental Testing (NLET) (Burlington, ON) by procedures equivalent to those described in Cancilla (1994) and EC (2008).

Surficial sediments (top 10 cm) were analyzed by Caduceon Environmental Laboratories (Ottawa, ON) for total mercury (cold-vapor atomic absorption, EPA method 7471A), trace elements (Inductively Coupled Plasma - Atomic Emission Spectroscopy, EPA method 6010), major oxides (whole rock, in house procedure), loss on ignition (in house procedure), total organic carbon (Leco method), total phosphorus (automated colorimetry EPA method 365.4) and total Kjeldahl nitrogen (semiautomated colorimetry, EPA method 351.2) (USEPA/CE 1981).

Sediment particle size was analyzed by EC's Sedimentology Laboratory (Burlington, ON) following procedures of Duncan and LaHaie (1979). Petroleum hydrocarbons (PHCs), polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs), were analyzed by ALS Laboratory Group (Waterloo, ON). PHCs were analyzed by GC/FIC based on CCME Canada-Wide Standards (CCME 2008). Parent PAHs and PCBs were determined by EPA 8270-GC/MS and alkylated PAHs (2010 samples only) by EPA 3540/8270-GC/MS (USEPA 2008). The 2009 oil and grease samples were analyzed by Method 5520 (APHA/WEF/AWWA 2005). The 2010 oil and grease samples were split samples sent to three separate laboratories. Samples were analyzed by the above 5520 method at two laboratories and using the primary reference of EPA 9071B (USEPA 2004) at the third laboratory.

2.3 Taxonomic Identification

Sorting, enumeration, identification (family level) and verification of benthic invertebrate samples were performed by EcoAnalysts, Inc. (Moscow, Idaho, USA). Certain taxa and microinvertebrates (e.g., poriferans, nematodes, copepods, and cladocerans) were excluded. Material was sorted under a dissecting microscope (minimum magnification = 10×), and organisms were enumerated and placed in vials for identification to lowest practical level by qualified NABs (North American Benthological Society) certified taxonomists.

2.4 Sediment Toxicity Tests

Four toxicity tests (bioassays) were performed at the Environment Canada's Ecotoxicology Laboratory in Burlington, ON:

1) *Chironomus riparius* 10-day survival and growth test;
2) *Hyalella azteca* 28-day survival and growth test;
3) *Hexagenia* spp. 21-day survival and growth test; and
4) *Tubifex tubifex* 28-day reproduction and adult survival test.

Sediments were initially sieved through a 250-µm mesh sieve prior to testing to eliminate native organisms which have been shown to interfere with toxicity responses (Reynoldson et al. 1994). Water chemistry variables (pH, dissolved oxygen (mg/L), conductivity (µS/cm), temperature (°C), and total ammonia (mg/L)) were measured for each test beaker (and each replicate) on day 0 (start of test – prior to introduction of organisms) and at completion of the test. Tests consisted of a 4: 1 ratio of overlying water to sediment for *Chironomus*, *Hyalella* and *Hexageni*a, and a 1.5: 1 ratio for *Tubifex*. Tests were run under static conditions in environmental chambers at 23 ± 1 °C, under a photoperiod of 16L: 8D and an illumination of 500 - 1000 Lux, except the *Tubifex* test, which was run in the dark. Control samples were run together with the test samples and control values plotted on a chart for each endpoint response. All tests passed acceptability criteria for their data to be used in the site assessments if control responses were within acceptable limits (± 2 standard deviations). Control samples consisted of a reference sediment collected from Long Point Marsh, Lake Erie. At test termination, sediment was passed through a 250-µm screen for *C. riparius* and *H. azteca*, 500-µm screen for *Hexagenia* and through a 500-µm and 250-µm sieve sequentially for *T. tubifex* to collect large worms and cocoons (on the 500 µm sieve) and small worms (on the 250 µm sieve). Amphipods, chironomids and mayflies were dried at 60°C to a constant weight. Test endpoints included percent survival and growth (increase in mg dry weight per individual) for *H. azteca*, *C. riparius* and *Hexagenia*. Initial weights of *H. azteca* and *C. riparius* were considered negligible. Initial mayfly wet weight was predicted to dry weight using a statistical model derived specifically for mayflies and growth was estimated as the difference between the initial and final dry weight. Test endpoints for *T. tubifex* included adult survival and reproduction which was assessed with three endpoints: total number of cocoons produced per adult, percent of cocoons that hatched, and total number of young produced per adult.

2.5 Data Analysis

Test sites were assessed using the BEAST model, a reference condition approach developed by Reynoldson et al. (1995, 2000). The BEAST model, which consists of 38 invertebrate families, predicts an invertebrate community group that should occur at a test site based on natural environmental conditions. Multiple discriminant analysis was used to predict the test sites to one of five Great Lakes reference community groups using a previously computed relationship between five environmental variables (latitude, longitude, depth, total organic carbon, and alkalinity) and predefined community groups (Reynoldson et al. 1995, 2000). For each test site, the discriminant model estimated a probability of it belonging to each of five reference faunal groups, so each site had five probability estimates. Community data for sites were then merged with the reference site invertebrate data of the matched reference group (group to which the test site has the highest probability of belonging, as defined by the discriminant model) only and ordinated using hybrid multidimensional scaling (HMDS) (Belbin 1993). The ordinations were performed with a Bray-Curtis similarity distance matrix, calculated on a site-by-site basis from the raw data. The ordination assessment was conducted at the family level, as this taxonomic detail is shown to be sensitive for the determination of stress (Reynoldson et al. 2000). Toxicity data (survival, growth and reproduction endpoints identified in Section 2.4) were also analysed using HMDS, with Euclidean similarity distance site × site distance matrix calculated from raw data standardized by range. Toxicity endpoints for the test sites were compared to those for 136 Great Lakes reference sites. Principal axis correlation (Belbin 1993) was used to examine relationships between habitat variables (those listed in Table 2 with the exception of the organic contaminants) and community family counts or toxicity responses. No organic contaminant data exist for the Great Lakes reference site and therefore a comparison to test sites cannot be made. Significant endpoints and environmental attributes were identified using Monte-Carlo permutation tests (Manly 1991). Test sites were assessed by comparing the data to confidence bands of appropriate reference sites. Probability ellipses were constructed around the Great Lakes reference sites, establishing four categories of measured differences from the reference sites: 1) equivalent /non-toxic (within a 90% ellipse), 2) possibly different/ potentially toxic (between 90 and 99% ellipses), 3) different/toxic (between 99 and 99.9% ellipses), and 4) very different/severely toxic (outside the 99.9% ellipse). Toxicological responses were also compared to numerical criteria previously established for each species (Reynoldson and Day 1998). Test data were analysed in subsets to maintain the ratio of test: reference sites ≤0.10. The multiple discriminant analysis indicated above and probability ellipse construction was performed using SYSTAT (Systat Software Inc. 2007). HMDS, principal axis correlation and Monte-Carlo tests were performed using PATN (Blatant Fabrications Pty Ltd. 2001).

Relationships between the toxicological response and the measurement variables (i.e., concentrations of individual or integrated compounds) were also examined using Partial Least Squares (PLS) regression, based on the Nonlinear Iterative Partial Least Squares (NIPALS) algorithm. The PLS regression is analogous to a combination of linear regression and principal component analysis where the dependent (response) variable(s) are regressed against a set of independent (predictor) variables. A set of plots (scores and loadings) is given that provide information about the correlation structures of the variables and structural similarities/dissimilarities among the compounds (Roy and Roy 2008). The dependant variables (*Y*) included toxicity test endpoints and the independent variables (*X*) included chemical and physical properties of the sediment. Separate PLS regressions were performed using the alkylated PAH data from 2010, as this data was not available for 2009 samples. The R^2, which represented the amount of explained variation for the toxicity endpoints, was used to assess the explanatory power of the physico-chemical properties of the sediment. To estimate the predictive ability of the model, v-fold cross-validation was performed. In v-fold cross-validation, repeated (v) random samples are drawn from the data for the analysis, and the respective model is then applied to compute predicted values (StatSoft Inc. 2011). The overall accuracy of the respective prediction model or method is represented by the Q^2 value and the statistical significance of a component was based on Q^2 exceeding the cross-validation threshold for that component, e.g., if Q^2 > limit (0 for PLS), the component was significant. PLS was performed using STATISTICA (StatSoft Inc. 2011).

The relationship between toxicological response (survival, growth and reproduction endpoints) and oil and grease, normalized to dry weight as well as normalized to volume, were also examined by regression analysis to address Study Objective 5 (Section 1.2). Simple linear regression analysis (ordinary least squares method) was performed in MINITAB (Minitab Inc. 2007).

To determine whether toxicity could be attributed to PAH mixtures in St. Marys River sediment, benchmark values were calculated using an equilibrium partitioning (EqP) and hydrocarbon narcosis models (USEPA 2003). Hazard quotients, referred to toxic units, were calculated by dividing the organic carbon normalized concentration of the individual PAH compound by the PAH-specific final chronic value (FCV) concentration provided in USEPA (2003). Quotients were then summed for the PAHs analyzed at each site to get the equilibrium partitioning sediment benchmark (ESB). For 2010 data, both the parent and alkylated forms of PAHs (total of 34 compounds) were used in the model. For 2009 data, this was based on parent compounds only since the alkylated PAHs were not measured. If the sum of the toxic units was greater than 1, the sediments were characterized as being likely to cause chronic toxicity from PAHs in the expose organisms (USEPA 2003).

2.6 Quality Assurance/Quality Control

Two sites were randomly selected as a QA/QC stations: EC33 (2009) and EC52 (2010). Triplicate water, sediment and benthic community samples were collected at these sites for determination of within-site and among-sample variability. The variation among the field-replicated analytical data was examined using the coefficient of variation (CV) which is the ratio between standard deviation and the mean multiplied by 100. Within-site variability in taxon diversity and abundance between box core samples was examined by comparing the position of the QA/QC sites in the ordination plots. The three replicate samples of sites EC33 and EC52 as well as their average were ordinated using HMDS as described above. Quality control procedures employed by analytical laboratories included the analysis of matrix and surrogate spikes, certified reference materials, isotopically labelled extraction standards, laboratory control samples and sample replicates. Precision of sample replicates was evaluated using the relative percent difference (RPD), defined as $RPD = (x_1 - x_2)/ (x_1 + x_2)/2) \times 100$.

For benthic invertebrate identification and enumeration performed by EcoAnalysts, Inc., 20-25% of every sample was re-sorted to achieve a 95% level sorting efficiency. At least one specimen of each taxon encountered was kept in a separate vial to comprise a project reference collection. Internal quality assurance of the identifications involved examination of the reference collection by a second taxonomist to verify accuracy of all taxa identified. Additionally, 10% of samples were randomly selected and re-identified by a QA taxonomist. Data entry involved visual confirmations of the taxonomic identification and number of specimens in each taxon. All data collected was entered directly on a computer database.

3 RESULTS AND DISCUSSION

3.1 Quality Assurance/Quality Control

Among-site variability in a measured analyte can be broken down into three sources: natural within-site heterogeneity in the distribution of the analyte in sediment or water, differences in handling among samples, and laboratory measurement error. Among-site variability indicates the overall "error" associated with conditions at a site based on a single sample. Variability among field-replicated sites (EC33 in 2009 and EC52 in 2010), expressed as the coefficient of variation (CV), is summarized in Appendix A (Tables A1 to A3). The CVs for trace metal and nutrient analysis were mostly low, ranging from 0 to 35% (median 2.8%) in 2009 and 0 to 39% (median 5.5%) in 2010 (Appendix A, Table A1). Most sample CVs (93%) were below 20%, indicating homogeneous conditions within a site, and good representation of the chemical conditions by the box core sampler. The CVs for organic contaminant measurements (e.g., PAHs, PHCs, oil and grease) were higher than those observed for trace metals/nutrients, ranging from 0.7 to 43.6% (median 12.2%) in 2009 (Appendix A, Table A2) and from 4.5 to 48.2% (median 25.4%) in 2010 (Appendix A, Table A3). The 2010 samples included the alkylated PAHs (not measured in 2009 samples).

Laboratory duplicate measurements for sediment trace metal/nutrients variables are provided in Appendix A, Tables A1. The RPDs ranged from 0 to 67%, (median 1.1 to 3.5%) with some higher values for molybdenum (2009) and beryllium and chromium dioxide (2010). Most RPDs (94 to 100% of samples) had CVs that were below 20%, indicating an acceptable level of reproducibility during sample analysis.

Due to the large amount of data, RPDs for laboratory replicates for organic contaminant samples as well as recoveries for laboratory control samples (LCS) and method blanks (MB) were not provided in this report, but can be made available upon request. The RPDs were quite low, ranging from 0 to 48% (median 4.0%) in 2009 and from 0 to 47% (median 6.2%) in 2010. Between 96 and 98% of samples had a RPD below 20%, and all values were below the RPD limit. Some RPDs were not available because results were below the detection limit. Percent recoveries for LCS were good, ranging from 67 to 142% (median 93%) in 2009 and from 63 to 113% (median 95%) in 2010 and were all within QC limits with the exception of one sample which was just slightly above the limit (142%; QC limit: 50-140). Due to the number of analytes, 10% may exceed QC limits, but only one sample marginally exceeded the QC limits. Recoveries could not be reported for all MB samples where result and target values were below reporting limits. The purpose of the MB is to control any source of contamination during the procedure and is a sample free of the analyte of concern of a matrix that is similar to the batch of associated samples; it is processed simultaneously with and under the same conditions as samples (through all analytical procedure) (Emerson Perez, ALS Laboratory Group, pers. comm.).

Analyses and recoveries for reference materials or standards (LKSD-3 and SS-1 (trace metals), LKSD-2 (Hg), WH89-1 (major oxides), D053-542 (total Kjeldahl N and total P), and TOC QC (TOC)) are provided in Appendix A, Table A4 (2009) and Table A5 (2010). Recoveries were mostly high, ranging from 30 to 130% (median 95%) in 2009 and from 61 to 106% (median 95%) in 2010. While the recovery was low for molybdenum in 2009 (30%), it was within the control limits (0 to 260%) for this variable and results for this metal were consistent to that found in 2008 (36% recovery; Milani and Grapentine 2010). Recoveries for all other variables were well within the control limits for each parameter.

To test the effects of the matrix and precision of the laboratories sample preparation, surrogate spikes were performed for sampling years 2009 and 2010. Prior to sample preparation, between 5 and 12 samples were spiked with the surrogate and analyzed. Surrogates varied from 2009 to 2010 and percent recoveries for these surrogate concentrations in the final sample extracts are provided in Appendix A, Table A6. Overall recoveries ranged from 85 to 121% in 2009 and from 44 to 210% in 2010. In 2009, the generally high recoveries indicated a good ability of the laboratory to analyze organic compounds. In 2010, the lowest recoveries were noted for the naphthalene d8 surrogate at some sites (one sample was slightly outside the data control limits but the reported non-detect results for associated samples were unaffected). The recoveries for the benzo(a)pyrene d12 surrogate (130 to 210%) were outside acceptable limits at most sites in 2010 due to matrix interferences.

Benthic community composition

Replicate samples of EC33 (2009) and EC52 (2010) were in very close proximity to each other in ordination space, indicating very good agreement in benthic community composition for the box-core field replicates (Appendix A, Figures A1 and A2). All replicates fell in the same band (Band 1) for both sites. These results indicate that the benthic invertebrate community within a site was well represented by the box core sample.

3.2 Overlying Water and Sediment Physico-Chemical Characteristics

3.2.1 Overlying Water

Physicochemical conditions in the overlying water (0.5 m above the sediment) were similar among sites suggesting homogeneity in the bulk water across sampling sites (Table 3). Ranges across sites (maximum minus minimum value) were 2.3 mg/L for alkalinity, 3 µS/cm for conductivity, 0.4 mg/L for dissolved oxygen, 3 mg/L for hardness, 0.05 mg/L for NH_3, 0.03 mg/L for NO_3/NO_2, 0.2 mg/L for total Kjeldahl nitrogen (TKN), 0.1 for pH, 1.0°C for bottom temperature, and 0.002 mg/L for total phosphorus. Total phosphorus (range: 4.9 to 7.3 µg/L) did not exceed the interim Provincial Water Quality Objective of 20 µg/L at any site. Similar results were found in 2008 (Milani and Grapentine 2010).

3.2.2 Sediment Particle Size

In 2009-2010, most sediment in EBMP consisted mainly of fines (silty clay); percent silt ranged from 28 to 95% (median 67%) and clay from 0.2 to 43% (median 32%) (Table 4). Site EC52, located in the most southerly east part of EBMP consisted of coarser silty sand (71% sand). No gravel was present at any site in EBMP (or in LGC). Sediment in LGC was also quite fine with the exception of site 170 (upper part of LGC), which was 98% sand. Remaining sites in lower LGC were very silty or were silty clay; silt ranged from 52 to 98% (median 92%) and clay from 0.2 to 40% (median 0.6%).

Particle size distribution from 2002 to 2010, from upstream locations (Izaak Walton and Point Aux Pins Bay) to LGC is provided in Fig. 2. The upstream reference area was generally coarser than the other areas of the river; however, about half the sites in BMP and the upper half of LGC were similarly coarse. The EBMP area of the river consists of very silty deposits, as does the lower part of LGC; therefore, it is reasonable to expect that benthic communities upstream could be different than those in EMBP and lower LGC regardless of contaminant concentrations. The range of sand, silt and clay fractions for Great Lakes reference sites (Gp 1) is quite large and encompasses test site characteristics; on average Gp1 reference sites consist mainly of silt and close to equal amounts of clay and sand (Fig. 2).

3.2.3 Sediment Trace Metals and Nutrients

In 2009-2010, metal exceedences of the Provincial Sediment Quality Guideline (SQG) Lowest Effect Level (LEL) (Fletcher et al. 2008) occurred for 2 to 9 metals in EBMP and for 0 to 8 metals in LGC (Tables 5a, 5b). Exceedences of the SQG Severe Effect Level (SEL) were limited to iron (Fe) at most EBMP sites and about a third of LGC sites. Metal concentrations were generally higher in EBMP than in LGC. Results are consistent with past sampling, where LEL exceedences were observed in the lower river, including BMP, for several metals (Milani and Grapentine 2009, 2010). There were no guideline exceedences for metals at the upstream reference sites sampled in 2010 (Table 5b).

Sediment nutrients were elevated in EBMP and LGC compared to the LELs. The LEL for total organic carbon (TOC), total Kjeldahl nitrogen (TKN) and total phosphorus (TP) of 1%, 550 µg/g and 600 µg/g, respectively (Fletcher et al. 2008) was exceeded at all test sites except one in LGC (site 170) (Tables 5a, 5b). In EBMP, TOC ranged from 4.8 to 8.0% (mean 6.7%), TKN from 2080 to 4310 µg/g (median 3385 µg/g) and total phosphorus (TP) from 602 to 758 µg/g (median 696 µg/g) (Tables 5a, 5b). Nutrient concentrations were lower overall in LGC, with TOC ranging from 0.6 to 4.8% (mean 3.5%), TKN from

527 to 3280 μg/g (median 1995 μg/g) and TP from 233 to 743 μg/g (623 μg/g). Similar results were found in 2008 (Milani and Grapentine 2010). The upstream reference sites, sampled in 2010, had lower nutrient levels than in EBMP and LGC, with TOC ranging from 0.9 to 1.8%, TKN from 932 to 1590 μg/g and TP was fairly low (below the LEL), ranging from 286 to 335 μg/g (Table 5b). From 2002 to 2010, TOC was elevated from BMP to LGC compared to the upstream and Great Lakes reference, with the exception of sites in the upper part of LGC (Fig. 3). The TOC at one reference site (site 52-479), sampled in 2002, was quite high at 7.6%, and woody chips were noted at this site. Site 52-479 was resampled in 2010 (approximately 11 m from the original 2002 site) and the TOC was much lower at 1.8% (Table 5b). The mean TOC was 4.3 to 4.5 times higher in BMP and EBMP than the upstream reference and 2.6 times higher than LGC.

3.2.4 Sediment Organic Contaminants

PAHs - Parent and Alkylated Compounds

For reporting purposes, total parent PAHs ($tPAH_{par}$) represents the sum of the 18 priority parent compounds and $tPAH_{34}$ represents the sum of the priority parent + 16 alkylated homologs. The 34 PAH compounds are recommended by USEPA (2003) to be analyzed when assessing PAH risk and includes the most common parent and alkylated frequently found in PAH mixtures. Reporting limits (RLs) for the parent and alkylated PAH compounds (as well as other organic compounds measured) are provided in Appendix A, Tables A7 and A8.

In EBMP from 2009-2010, $tPAH_{par}$ ranged from 18.64 to 38.45 mg/kg (Table 6a). These values were within the range observed in 2008 in this area, where $tPAH_{par}$ ranged from 10.8 to 51.9 mg/kg (Milani and Grapentine 2010). Exceedences of LELs for individual PAHs occurred at all sites for all PAHs with the exception of fluorene at a few sites (Table 6a). Examination of PAH patterns showed that fluoranthene (11-13% of $tPAH_{par}$) and pyrene (10-12% of $tPAH_{par}$) dominated, although some samples had high naphthalene concentrations as well (4-19% of $tPAH_{par}$). For 2010 sites where there were data for parent and alkylated homologues (n=5), the parent compounds dominated at 59-65% to $tPAH_{34}$. The alkylated PAH concentrations (16 homologues) ranged from 12.67 to 19.58 μg/g, $tPAH_{par}$ from 20.04 to 29.47 μg/g and $tPAH_{34}$ from 32.86 to 47.66 μg/g (Fig. 4, Tables 6a, 6b). The highest concentrations of alkylated PAHs were the C4 Phenanthrenes/Anthracenes (Phe/Ant), which ranged from 2.45 to 5.69 μg/g, followed by the C1 Fluoranthenes/Pyrenes (Fl/Py), which ranged from 1.16 to 1.88 μg/g. Other than C1-C3 Phe/Ant and C1 Benz(a)Ant/Chrysenes, most concentrations of remaining alkylated homologues were <1 μg/g (Table 6b).

In LGC from 2009-2010, $tPAH_{par}$ ranged from 0.5 to 25.4 mg/kg (Table 6c). Exceedences of LELs for individual PAHs occurred at all 2009-2010 sites except site 170 (Table 6c), which is located in the upper part of LGC and consisted of coarse sediment (97.6% sand) (Table 4). The dominant parent PAHs in EBMP samples were the same as that seen for EBMP, with fluoranthene the most abundant (10-18% of $tPAH_{par}$) followed by pyrene (8-14% of $tPAH_{par}$). Parent and alkylated PAHs concentrations were overall lower in LGC than those found in EBMP. For 2010 sites, where there were data for parent and alkylated compounds (n=5), the parent compounds dominated at 58-63% to $tPAH_{34}$, similar to that found in EBMP. The alkylated PAH concentrations (16 homologues) in LGC ranged from 7.86 to 14.29 µg/g, $tPAH_{par}$ from 11.93 to 24.34 µg/g and $tPAH_{34}$ from 19.80 to 38.63 µg/g (Fig. 4, Tables 6c, 6d). Both parent and alkylated PAH compounds increased with distance downstream in LGC (Fig. 4).

Total PAH_{par} concentrations at upstream reference sites sampled in 2010 were low, ranging from 0.27 to 0.41 µg/g (Table 6c), alkylated PAHs (16 homologues) ranged from 0.14 to 11.65 µg/g and $tPAH_{34}$ from 0.49 to 12.05 µg/g (Table 6d). Three of the four upstream reference sites had $tPAH_{34} \leq 2.95$ µg/g. The increase in $tPAH_{34}$ from $tPAH_{par}$ was attributed to C4 Phenanthrenes/Anthracenes, which was high at site 52-479 (11.2 µg/g) and similar to concentrations found in LGC (Table 6d). Site 52-479, as well as site EC56, had wood debris present in the sediment sample, whereas the two other upstream sites did not.

Concentrations of C1-C4 Phe/Ant in EBMP and LGC, which ranged from 5.76 to 10.56 µg/g, and 3.09 to 6.45 µg/g, respectively, were an order of magnitude higher than those found in demonstration ponds and wetlands on oil sand mine leases, which ranged from 0.119 to 0.970 µg/g (Smits et al. 2000). The C1-C4 Phe/Ant concentrations were also higher those found in 2 of the 3 tributaries of the Athabasca River, where ~ 1.8 µg/g, ~3 µg/g and ~ 16 µg/g were reported for sediments from the Lower MacKay, Ells and Steepbank Rivers (Headley et al. 2001). However, the parent PAH compounds dominated in St. Marys River samples. The greater abundance of parent PAH compounds compared to their alkyl homologues and a PAH distribution dominated by the 3, 4 and 5 ring compounds, such as fluoranthene and pyrene, is indicative of a combustion-related source (Page et al. 1999; Thorsen et al. 2004). As indicated above, Fl and Py were the dominant parent PAHs in EBMP and LGC. Examination of PAH ratios can also be used to distinguish between combustion-derived (pyrogenic) and petroleum-derived (petrogenic) sources (Yunker et al. 2002; Pies et al. 2008). Cross plots of the Fl / (Fl + Py) ratio against the Ant/ (Ant + Phe) ratio were examined (Fig. 5a) as well as the C_0/ (C_0 + C_1) (Phe /Ant), where C_0 and C_1 are the parent and C1 homologue concentration, respectively, against the Fl (Fl +Py) ratio (Fig. 5b). Generally, an Ant to Ant + Phe ratio < 0.10 indicates a petroleum source and a ratio > 0.10 a combustion source whereas the transition point for both Fl to Fl + Py and C_0/ (C_0 + C_1) (Phe and Ant) is 0.50 (Yunker et al. 2002). Ratios for 2009-2010 EBMP and LGC sites were > 0.10 for Ant/Phe and > 0.50 for Fl/Py, indicating the PAH source to be combustion derived (Fig. 5a). The ratios for 2010 EBMP and LGC sites for $C_0/(C_0 + C_1)$ (Phe and Ant) were also > 0.50 further indicating that the source was combustion-derived.

Total PAH_{par}: 2002 to 2010

The $tPAH_{par}$ concentrations from upstream locations (Izaak Walton and Point Aux Pins Bay) to LGC are shown in Fig. 6. Overall, the highest $tPAH_{par}$ occurred in EBMP, which ranged from 3.4 to 51.9 mg/kg (median 18.8 mg/kg). The concentrations of $tPAH_{par}$ in BMP and LGC were similar, ranging from 2.3 to 30.6 mg/kg (median 4.3 mg/kg) and 0.5 to 25.4 mg/kg (median 5.5 mg/kg), respectively. All areas of the lower river were elevated compared to the upstream reference locations, which ranged from 0.27 to 0.41 mg/kg (median 0.18 mg/kg) (Fig. 6). The upper 99^{th} percentile PAH concentration for the upstream reference sites (0.40 mg/kg) was exceeded at all test sites (only marginally at site 170 in LGC).

BTEX and Petroleum Hydrocarbons (PHCs)

In EBMP for 2009-2010, BTEX (benzene, toluene, ethylbenzene and xylene) and F1 PHCs (C6-C10 hydrocarbons) were mostly below RLs (values preceded by "<") at all sites (Table 6a). Reporting Limits for BTEX and PHCs are provided in Appendix A (Tables A7 and A8). The F2 (C10-C16 hydrocarbons) PHCs were detected at 6 of the 13 sites, ranging from 13 to 111 mg/kg. The F3 (C16-C34 hydrocarbons) and F4 (C34-C50 hydrocarbons) fractions were detected at all sites, ranging from 397 to 3260 mg/kg, and from 180 to 3150 mg/kg, respectively. The gravimetric heavy hydrocarbons (F4G: ~C24-C50+), which typically include the very heavy hydrocarbons (e.g., heavy lubrication oils, asphaltenes) were also detected at all sites, ranging from 620 to 5700 mg/kg. The chromatogram did not reach baseline at C50 at any site (i.e., there were PHCs present with carbon chain lengths >50), indicating the presence of very heavy hydrocarbons in EBMP. Total PHCs (C6 to C50 hydrocarbons) ranged from 590 to 6510 mg/kg (median: 2440 mg/kg).

In LGC for 2009-2010, the BTEX and F1 PHCs were also mostly below RLs at all LGC sites (Table 6c). The F2 fraction was detected at 6 of the 9 sites, ranging from 33 to 182 mg/kg. The F3 fraction was detected at all test sites, ranging from 61 to 9810 mg/kg (overall higher in LGC than in EBMP). The F4 fraction was detected at all sites except one in LGC (site 170); concentrations ranged from 240 to 6770 mg/kg. The F4Gs were detected at all but one site (site 170), ranging from 980 to 2900 mg/kg. The chromatogram did not reach baseline at C50 at 7 of the 9 sites; the upper and lower LGC sites (sites 170 and 6901) reached baseline. In between these two sites, there were very heavy hydrocarbons present in the channel. Total PHCs ranged from 61 to 16800 mg/kg (median: 2070 mg/kg).

Sediment PHC concentrations were compared to the CCME soil guidelines, a remedial standard for contaminated surface soil for different land use categories (industrial, residential/parkland, commercial, agricultural) and soil textures (coarse=median grain size > 75 µm; fine=median grain size ≤75 µm) (CCME 2008). In cases where both the F4 and F4G results are reported (as for this study), the greater of the two was compared to the F4 guideline. Petroleum hydrocarbon concentrations were compared to the numerical levels for the residential/parkland land use category as this was deemed most suitable for the lower areas of St. Marys River. The CWS for each PHC fraction (fine-grained) are provided in Tables 6a, 6c. For the F3 fraction, exceedence of the standard occurred at 8 of the 13 sites in EBMP (up to ~2 times) (Table 6a) and at 4 of the 9 sites in LGC (up to 7.5 times) (Table 6c). For the F4 fraction, no sites exceeded the standard in EBMP and 1 site exceeded in LGC (site EC49) by 1.2 times.

Total PHCs: 2002 to 2010

Total [PHC]s were quite elevated in all areas of the river compared to the upstream reference locations, ranging from 189 to 8450 mg/kg (median 1456 mg/kg) in BMP, from 590 to 7570 mg/kg (median 1785 mg/kg) in EBMP, and from 32 to 16800 mg/kg (median 1716 mg/kg) in LGC (Fig. 7). Upstream reference site [PHC]s ranged from below the detection limit (50 mg/kg) to 341 mg/kg (median 39 mg/kg). The upper 99th percentile PHC concentration for the upstream reference sites (318 mg/kg) was exceeded at 92% of test sites; some sites in BMP and LGC were below the 99th percentile (or just marginally above) while and all sites EBMP were above.

Oil and Grease

From 2009 to 2010, oil and grease concentrations ranged from 2310 to 15100 mg/kg (median 8570 mg/kg) in EBMP (Table 6a), higher than concentrations found in LGC, which ranged from <500 to 8850 mg/kg (median 4345 mg/kg). In the upstream reference area, oil and grease concentrations were lower and ranged from 560 to 2090 mg/kg (Table 6c). Examination of 2009 data in EBMP revealed that oil and grease concentrations in 2009 were up to an order of magnitude higher than those observed in 2008, which ranged from 300 to 1300 mg/kg (Milani and Grapentine 2010). This coincided with a change in extraction techniques by the laboratory performing the analysis (a hot extraction technique was changed to a cold extraction). In 2010, split samples from all sampling locations were sent to two or three laboratories for oil and grease determination (see Section 2.1). Results for these split samples are provided in Fig. 8. Two of the three laboratories showed fairly good agreement (Labs 1 and 2), while the third lab (Lab 3) showed consistently higher concentrations for all test sites (Fig. 8). Differences between Labs 1 and 2 ranged from 10 to 2200 mg/kg, while differences between Labs 1 and 3 ranged from 570 to 10270 mg/kg and differences in Labs 2 and 3 ranged from 550 to 10000 mg/kg. Split samples from the four upstream reference sites (6903, EC56, EC57, 52-479) were sent to two laboratories (Lab 1 and 3) and the values showed good agreement between the two labs (Fig. 8). Generally sites with lower total oil and grease concentrations showed better agreement between labs (see site EC52 in addition to the reference sites).

Oil and Grease: 2006 to 2010

Total oil and grease concentrations from 2006 to 2010 (samples were not analyzed for oil and grease in 2002) are shown in Fig. 9. For 2010 split samples, the average concentration of the three laboratories was used. Overall, oil and grease concentrations in EBMP ranged from 300 to 14000 mg/kg (median 1458 mg/kg) and in LGC ranged from 108 to 4900 mg/kg (median 1210 mg/kg). Concentrations in BMP, which ranged from 141 to 927 mg/kg (median 376 mg/kg), were more similar to those found in the upstream reference locations, which ranged from 0 to 1995 mg/kg (median 595 mg/kg). The upper 99th percentile of upstream reference oil and grease concentrations (1946 mg/kg) was not exceeded for any sites in BMP, while 46% and 44% of sites were above the 99th percentile in EBMP and LGC, respectively. Regardless of how the oil and grease data were pooled, across all years, or if readings were pooled across two or three laboratories, all the results show that oil and grease concentrations were elevated in EBMP compared to other areas of the river.

PCBs

Total PCBs were detected at three sites in EBMP, ranging from 0.14 to 0.17 mg/kg (Table 6b), around twice the LEL of 0.07 mg/kg. Samples consisted mainly of Aroclor 1260 (Table 6b). Total PCBs were below RLs at Lake George Channel and upstream reference sites (Table 6d). Results are similar to previous years where total [PCB]s were below detection in 2008 (Milani and Grapentine 2010) and were low in EBMP (n=2) and in LGC (n=3) in 2006, ranging from 0.10 to 0.14 µg/g and from 0.02 to 0.03 µg/g, respectively (Milani and Grapentine 2009).

3.3 Benthic Invertebrate Community Composition

All St. Marys River sites (2009-2010) were predicted to reference Group 1 based on the habitat attributes (alkalinity, depth, total organic carbon, latitude and longitude), with the probability of group membership ranging from 72 to 94% (Table 7). Great Lakes Reference Group 1 is characterized by the midge Chironomidae (~40% occurrence), the oligochaete worm Tubificidae (~17% occurrence), and the fingernail clam Sphaeriidae (~15% occurrence). To a lesser degree, the isopod Asellidae, the oligochaete worm Naididae and the polychaete worm Sabellidae also present in Group 1 (between ~4 to 6% occurrence). Other families such as the amphipods Pontoporeiidae and Gammaridae, the snail Valvatidae and the zebra mussel Dreissenidae are present occasionally (≤ 2% occurrence) in reference Group1 Tables 8a and 8b show the abundance per area of the sampling core tube (number per 33cm^2) for St. Marys River sites. Complete invertebrate family identification and average counts for all taxa found in 2009-2010 St. Marys River samples are provided in Appendix B; Tables B1 and B2.

In EBMP, samples consisted mainly of chironomids, ranging in abundance from 3 to 59 per 33 cm^2 (905-17,803 per m^2) and tubificid worms, ranging from 8 to 93 per 33 cm^2 (2414-28,063 per m^2), mostly in increased abundance compared to GL reference sites (increases of up to 4.4× for chironomids and up to 16.6× for tubificids) (Table 8a). Chironomid abundances at test sites, however, were more similar or lower to that observed at the 2010 upstream reference sites (n=4), which ranged from 27 to 110 cm^2 (mean: 48.6 per 33 cm^2 or 14,665 per m^2) (Table 8b). Tubificid densities at the upstream sites, which ranged from 2 to 17 per 33cm^2 (mean 6.9 per 33 cm^2 or 2082 per m^2), were generally lower than those at test sites and were similar to GL reference densities. Naidid worms were also present at all test sites (0.6-31 per 33 cm^2), and sphaeriids at 7 of the 11 sites (0.2-1.2 per 33 cm^2); asellids, sabellids, amphipods (Hyalellidae, Gammaridae), mayflies (Ephemeridae) and caddisflies (Leptoceridae) were present at ≤50% of sites. Mayflies were present at all 2010 upstream reference sites, amphipods were present at ¼ of the sites and no caddisflies were found. The generally more pollution sensitive groups such as ephemeropterans, trichopterans and amphipods were present at 2 or 3 of the 11 sites in EBMP. The number of macroinvertebrate families present (based on the 38-family bioassessment model) ranged from 5-16 for sites in EBMP (Table 8a) compared to 8-13 for upstream reference sites (Table 8b); 6 of the 11 EBMP sites had a lower number of families present than upstream reference sites as well as the mean of the GL reference sites (8 taxa) (Table 8a).

The results of the multivariate assessment of 2009-2010 EBMP sites are summarized in Table 8a. Ordination plots are provided in Appendix C, Figs. C1 - C3; each subfigure representing 3 or 4 test site data. Three axes adequately described the variation in all data. Stress, which is a measure of the goodness of fit between the distances among points in ordination space and the matrix input distances, ranged from 0.15 to 0.16. The larger the disparity the larger the stress and stress > 0.20 is considered poor (Belbin 1993). Results were as follows:

<u>EBMP 2009-2010 (n=11)</u>

Band 1 (inside 90% ellipse - equivalent)	5 sites (EC33, EC37, EC52-54)
Band 2 (between 90 & 99% ellipse - possibly different)	5 sites (EC30, EC32, EC34-36)

Band 3 (between 99 & 99.9% ellipse - different) 0 sites
Band 4 (outside 99.9% ellipse - very different) 1 site (EC31)

Five sites are inside the 90% ellipse and considered equivalent to reference (Appendix C, Figs. C1 - C3). Site EC31, outside of the 99.9% ellipse, has increased abundance of oligochaete worms (Appendix C, Fig. C1) while the 5 sites between the 90 and 99% ellipses have increased abundance of tubificids and chironomids (Appendix C, Fig. C2). Tubificids and chironomids contributed most significantly ($p< 0.01$) to the ordination analysis. The relationship between the benthic community responses and habitat variables (excluding organic contaminants) was examined by correlation of the results from the ordination of the taxonomic data with the habitat information. The most highly correlated variables ($p< 0.01$) are shown in each figure (Appendix C, Figs. C1 - C3) and included sediment Hg, sample depth, and overlying water alkalinity and NO_3/NO_2, very similar to that found in 2008 (Milani and Grapentine 2010). Those variables oriented with the position of EBMP sites included Hg and perhaps alkalinity and NO_3/NO_2, but correlations were not strong (r^2=0.10 to 0.15), explaining at most 15% of the variation.
.
In LGC, sites also consisted primarily of chironomids and tubificids worms (Table 8b). With the exception of one site (site 170), densities of chironomids were similar to those found in EBMP, ranging from 5 to 34 per 33 cm^2 (1509-10,260 per m^2); site 170 had a much higher density of chironomids at 204 per 33 cm^2 (61,557 per m^2). Tubificid densities ranged from 3-113 per 33cm^2 (905-34,098 per m^2), fairly similar to densities found in EBMP (Table 8a) and much higher than those observed at the upstream reference sites (Table 8b). Naidid worms were also present at all sites in LGC (0.4-32 per 33 cm^2) and had similar densities to that found in EBMP. Sphaeriids and sabellids were not as prevalent in LGC as they were in EBMP. The number of macroinvertebrate families present (based on the 38-family bioassessment model) ranged from 5-15 at sites in LGC; 5 sites had the same, similar or higher diversity than the GL reference mean (8 taxa) and upstream reference sites (8-13 taxa) (Table 8b).

The results of the multivariate assessment of 2009-2010 LGC sites are summarized in Table 8b. Ordination plots are provided in Appendix C (Figs. C4 and C5); each subfigure representing 4 or 5 test site data. As with EBMP data, three axes adequately described the variation in all data. Results were as follows:

<u>LGC 2009-2010 (n=9)</u>
Band 1 (inside 90% ellipse - equivalent) 5 sites (EC47, EC48, EC50, EC51, 6901)
Band 2 (between 90 & 99% ellipses - possibly different) 2 sites (EC38, EC49)

Band 3 (between 99 & 99.9% ellipses - different)	2 sites (170, EC39)
Band 4 (outside 99.9% ellipse - very different)	0 sites

Five sites were inside the 90% ellipse and considered equivalent to reference (Appendix C, Figs. C4 and C5). Two sites were in each of Bands 2 and 3 and had increased abundance of tubificid worms, chironomids or both (Appendix C, Figs. C4 - C5); tubificids and chironomids contributed most significantly ($p < 0.01$) to the ordination analysis. Between 6 and 12 variables were significantly correlated ($p < 0.01$) with the ordination axes scores. The most highly correlated variables were the same as those found for EBMP sites (Hg, depth, NO_3/NO_2, alkalinity) but correlations were fairly weak (r^2: 0.10 to 0.15).

The 2010 upstream reference sites (n=4) were also analyzed and summarized for 2 of the 3 axes (Appendix C, Fig. C6). Three of the four sites were inside the 90% ellipse (Band 1) and one site (6903) was outside the 90% ellipse (Band 2); this site had increased abundance of chironomids. Generally the same habitat variables that were significant ($p < 0.01$) for EBMP and LGC sites were significant for the upstream sites; however, habitat variables were not oriented with the position of the sites (Fig. C6). The upstream reference sites had high diversity with 9 to 18 families present (Table 8b).

Benthic community structure BEAST categories for BMP, EBMP and LGC sites are shown spatially in Figs. 10a, 10b, and 10c, respectively.

Relative Abundance and Taxon Diversity: 2002 to 2010

The relative abundance of key taxa for the four areas of the river (upstream reference, BMP, EBMP and LGC) and the GL reference Group 1 are shown in Fig. 11. The benthic composition for EBMP and LGC sites were most dissimilar to the GL and upstream reference sites, with higher percentages of tubificid (36-52%) and naidid worms (7-8%) compared to reference sites (tubificids: 14-22%; naidids: 3.5-5%) and lower percentages of most key taxa. Other taxa, which included mostly mites, dipterans (other than chironomids) annelids (other than tubificids and naidids) and asellids, were also lower in EBMP and LGC (2.7-2.8%) compared to reference sites (7.1-7.6%). Benthic composition in BMP was improved over EBMP and LGC and was more similar to that found at reference sites, consisting of a lower percentage of tubificids (32%) and slightly higher percentage of amphipods (2.5% compared to 0.4-0.7% abundance for EBMP and LGC, respectively). The percentage of other taxa at BMP (8.6%) was also similar to reference sites. There was a greater percentage of mayflies at upstream reference sites (5.8%) compared to all other areas of the river, which were similar in mayfly composition (0.7-1.0%), while the percentage of caddisflies were slightly higher in the downstream areas of the river (0.42-0.45) than the upstream reference area (0.2%). Taxon diversity from 2002 to 2010 is provided in Fig. 12. In BMP, taxon diversity did not fall below 2 standard deviations (SD) from the GL mean or upstream mean and overall this area (of the lower river) has the highest diversity (7-19 taxa; median 12.5 taxa). In EBMP, diversity declines (3-15 taxa, median 6 taxa) with more than half the sites below 2 SD from the upstream mean; this area has the lowest diversity. In LGC, diversity (4 to 18 taxa, median 9 taxa) was also lower than in BMP but is higher than EBMP; about 29% of sites were below 2 SD from the upstream reference mean.

3.4 Sediment Toxicity

Mean species survival, growth and reproduction from 2009/10 toxicity tests are provided in Table 9. Effects on the midge *Chironomus* (acute) and mayfly *Hexagenia* (chronic) were mostly restricted to EBMP, while effects on the amphipod *Hyalella* (acute and chronic) and the worm *Tubifex* (chronic) were evident in both EBMP and LGC. Effects on the worm *Tubifex* included low cocoon hatching success and low numbers of young produced. Minor effects were observed at the upstream reference sites, with a slight reduction in amphipod and midge survival at a few sites (Table 9). The multivariate assessment of test and reference site endpoints is provided in Appendix D (Figs. D1 - D6), with each figure representing the assessment of a subset of test data (3 to 5 site data). Stress was ≤ 0.12, indicating that the resultant three axes represented the original 10-dimensional (i.e., 10 test endpoints) among-site resemblances well. Resultant categories were as follows (summarized in Table 9):

<u>EBMP 2009-2010 (n=11)</u>

Band 1 (inside 90% ellipse - non-toxic)	1 site (EC36)
Band 2 (between 90 & 99% ellipses - potentially toxic)	4 sites (EC37, EC52-54)
Band 3 (between 99 & 99.9% ellipses - toxic)	1 site (EC30)
Band 4 (outside 99.9% ellipse - severely toxic)	5 sites (EC31-EC35)

<u>LGC 2009-2010 (n=8)</u>

Band 1 (inside 90% ellipse - non-toxic)	4 sites (EC38, EC49, EC51, 6901)
Band 2 (between 90 & 99% ellipses - potentially toxic)	1 site (EC50)
Band 3 (between 99 & 99.9% ellipses - toxic)	0 sites
Band 4 (outside 99.9% ellipse - severely toxic)	3 sites (EC39, EC47, EC48)

In EBMP, one site was non-toxic, four sites showed evidence of mild toxicity and six sites showed strong toxicity. The toxic and severely toxic sites (EC30 to EC35) were correlated with multiple endpoint affects such as reduced *Chironomus* and *Hyalella* survival and/or reduced *Tubifex* young production and percentage of hatched cocoons, as indicated in the ordination plots by the shift of these sites away from the reference centroid in the opposite direction to these vectors (Appendix D, Figs. D1 - D3). From 2 to 4 variables (combinations of Hg, TOC, Co, total P (sediment), TKN (sediment), depth) were significantly ($p< 0.01$) correlated to the ordination axes, although correlations were not strong ($r^2 = 0.08$ to 0.15), explaining at most 15% of the variation. From Figure D3, elevated levels of Hg and TOC appear associated with some site positions (sites EC52-54) but again, these correlations were not strong. Total Hg concentrations were fairly low at these sites (below LEL) ranging from 0.09 to 0.13 mg/kg and TOC ranged from 3.0 to 6.2% (Table 5b).

In LGC, four sites were non-toxic, one site showed evidence of mild toxicity and three sites showed severe toxicity. The severely toxic sites were correlated with low *Hyalella* survival (EC47, EC48) or reduced percentage of hatched *Tubifex* cocoons (EC39) (Appendix D, Figs. D4 and D5). From 3 (Hg, Depth, TOC) to 6 variables (previous + Ni, sand, Co) were significantly correlated ($p < 0.01$) to ordination axes; as with sites in EBMP, correlations were not strong ($r^2 = 0.08$ to 0.18) but elevated TOC appears associated with 2010 site positions (Fig. D5); TOC ranged from 4.2 to 5.5% at 2010 sites (Table 5b).

Upstream reference sites (n=4) were either non-toxic (3 sites) or potentially toxic (EC56) (Table 9, Appendix D, Fig. D6). Upstream site EC56 likely fell into the potentially toxic category due to the combined minor reduction in survival of *Chironomus* and *Hyalella*; a reduction in survival of *Hyalella* alone did not affect the overall outcome for site 52-479, which was categorized as non-toxic.
Sediment decision-making framework rankings for all BMP, EBMP and LGC sites are shown spatially in Figs. 13a, 13b, and 13c, respectively. For BMP sites, sampled in 2002 and 2006, acute toxicity to *Chironomus* was evident at 2 sites (6986, 6991) sampled in 2002 (Milani and Grapentine 2006). When these 2 sites were revisited in 2006, no toxicity was evident (Milani and Grapentine 2009). This likely reflects small scale heterogeneity in the area as sites were from 5 to 8.5 m apart between sampling years. Growth reduction in the mayfly *Hexagenia* was observed for both 2002 and 2006 at these sites (Milani and Grapentine 2006; 2009).

Toxicity-Contaminant Relationships

Partial Least Square (PLS) regression analysis is particularly useful for data sets with fewer observations (n = 12-23 site data) than predictor variables (n = 14 to 27 variables). It can be used as a tool to find the few underlying predictor variables which account for most of the variation in response. As such, PLS was used in the present study to elucidate underlying predictors which could account for the observed variation in toxicity response. Toxicity endpoints (*Hexagenia* growth, *Chironomus* survival, *Hyalella* survival, *Tubifex* % cocoons hatched and young production) (*Y*) were regressed against contaminant concentrations (9 trace metals, total phosphorus, total Kjeldahl nitrogen, % total organic carbon, percents sand, silt and clay, PHCs, alkylated and parent PAH compounds, oil and grease) (*X*) for the 2009-2010 data sets. Concentrations of PAHs included the sum of parent PAHs ($tPAH_{par}$), and for the 2010 data set, the sum of 18 parent + 16 alkylated PAHs ($tPAH_{34}$). Individual PAHs and alkylated PAHs were also examined. Concentrations of PHCs included the sum of those with carbon chain lengths between C6 to C50 (tPHC). The R^2 of *X* and *Y* was used to assess the explanatory power and the Q^2 the predictive ability of the model using cross-validation (See Section 2.5).

When the relationship between integrated organic contaminants, metals, nutrients and particle size and toxicity endpoints was assessed for combined 2009 and 2010 data, the first component was significant ($R^2Y = 0.17$, $R^2X = 0.69$, $Q^2 = 0.12$) (Appendix E, Fig. E1). The loadings for the variables were all negative, except for % sand which showed a positive correlation. Most variables had very similar loadings with the exception of % silt and tPHCs. Total PHCs had a larger loading for component 2, but this component was not significant. *Tubifex* young production (no. young per adult) and % cocoons hatched showed the greatest response (highest positive scores) while *Chironomus* survival and *Hexagenia* growth showed similar responses. When the relationship between individual parent PAHs and individual toxicity endpoints was assessed, the first component was significant (Appendix E, Fig. E2) ($R^2Y = 0.16$, $R^2X = 0.79$, $Q^2 = 0.12$). The parent PAHs had similar negative loadings, and toxicity endpoints had positive scores for component 1 (Appendix E, Fig. E2). *Tubifex* young production showed the greatest response to the parent PAHs followed by *Hexagenia* growth (highest positive scores). While the first components were significant, the amount of variation in toxicity response explained was fairly low in both cases ($R^2Y = 0.16 – 0.17$).

When the relationship between individual parent and alkylated PAHs and toxicity endpoints was assessed (separately) for 2010 data, the first components were significant (Appendix E, Figs. E3 and E4). The loadings were positive and very similar for PAHs and alkylated PAHs (PAHs: $R^2Y = 0.24$, $R^2X = 0.90$, $Q^2 = 0.18$; Alkylated PAHs: $R^2Y = 0.23$, $R^2X = 0.88$, $Q^2 = 0.16$) with the exception of Retene (Appendix E, Fig. E3) and C4 Phenanthrenes/Anthracenes (Appendix E, Fig. E4). *Tubifex* % cocoons hatched and *Tubifex* young production endpoints had the highest scores (negative) followed by *Hexagenia* growth. *Hyalella* and *Chironomus* survival had positive scores. Thus *Tubifex* showed the strongest response to PAHs with a decrease in hatched cocoons and young production correlated with elevated PAHs (parent and alkylated); survival of *Chironomus* and *Hyalella* did not show this relationship. However the amount of variation explained was again relatively low (R^2Y = 0.23 – 0.24) and it could not be distinguished which PAH compound had the greatest effect on toxicity since the compounds had all very similar loadings.

To further examine the potency of sediment PAHs, toxic units (TUs) were computed for each site for the 2009-2010 data. All sites had ∑TUs < 1 indicating that PAHs were not likely to have contributed to chronic toxicity with the exception of sites EC52 (TU=1.6-2.6) and EC53, which just slightly exceeded 1 (TU=1.1) (Table 10). Site EC52 (located in the southeast part of EBMP) consisted of coarse sediment (71% sand; Table 4) with low TOC (3%; Table 5b) compared to the other sites at EBMP and [PAH] was the second highest in this area ($tPAH_{34}$ = 45.4; Table 6b), which likely accounted for the larger TU for this site. There was chronic toxicity to *Tubifex* at sites EC52 and EC53 (Table 9); however, acute and chronic toxicity, observed at several other sites in EBMP and LGC, was not consistent with PAH contamination since the TUs were below 1 at these sites. An evaluation of matching sediment chemistry and biological effects indicates you do not see consistent effects until you get to approximately 5-8 TUs (Scott Ireland pers. comm.). It is possible that the alkylated PAHs and/or parent PAHs could have contributed to observed toxicity; but based on the large amount of unexplained variability from the PLS regressions coupled with the inconsistent results with respect to TUs, it is unlikely that the adverse effects seen at some sites was from PAHs.

Research conducted by the USEPA has shown that there could be a physical effect of oil on benthic invertebrates (reduced *Chironomus* biomass) and that toxicity correlated well with solvent extractables normalized to sediment volume (Mount et al. 2009). The relationship between toxicological response and oil and grease, normalized to dry weight and volume, was therefore examined in the current study using 2008 to 2010 data. Oil and grease normalized to volume was found to correlate better with *Hexagenia* growth (R^2 = 0.147, p = 0.03) and *Tubifex* young production (R^2 = 0.128, p = 0.04) than the concentrations of these contaminants normalized to dry weight (R^2 of 0.08 and 0.11, p = 0.12 and 0.06, respectively) (Appendix E, Figs. E5 and E6). However, correlations were weak regardless. There was no significant correlation found between *Chironomus* growth and oil and grease normalized to dry weight or volume (Appendix E, Fig. E7).

Previous examination of toxicity-contaminant relationships showed varied results between studies (Milani and Grapentine 2006, 2009, Bedard and Petro 1997). While certain contaminants correlated fairly well with toxicity in some cases, none of the contaminants could be identified as the singular cause of toxicity. In 2006, for example, variability in mayfly growth was almost equally well explained by elevated sediment zinc concentrations (r^2=0.47, p=0.005) and elevated TOC (r^2=0.47, p=0.002) (Milani and Grapentine 2009). For the 2006 chironomid model, elevated zinc concentrations in overlying water explained most of the variability in growth (r^2=0.63, p<0.0001). In the 1995 and 2002 toxicity studies, PHC concentrations were found to be the best singular predictor of toxicity for the sediments of Bellevue Marine Park, although a combination of chemical and physical characteristics of the sediment further helped to explain toxicity (Bedard and Petro 1997; Milani and Grapentine 2006). In 2008, toxicity endpoints were most strongly correlated to metal contaminants (As, Fe or Hg depending on the test endpoint), although these metals were not overly elevated in the sediment (Milani and Grapentine 2010).

3.5 Integration of Lines of Evidence: 2002 to 2010

In accordance with the Canada-Ontario Sediment Decision-Making Framework (EC/MOE 2007) a decision matrix was developed for the 2009-2010 study sites based on the three lines of evidence (sediment chemistry, toxicity, benthic invertebrate community structure). Interpretation of the overall assessment considered the degree of degradation for each line of evidence. Decision matrix tables for Bellevue Marine Park, East Bellevue Marine Park and Lake George Channel are shown in Tables 11a, 11b and 11c, respectively. Results from previous studies (2002 to 2008) were also included in the tables.

For the sediment chemistry column of Tables 11a, b & c, sites with exceedences of the Provincial Severe Effect Level (SEL) or the Canadian Probable Effect Level (PEL) were indicated by "■"; exceedences of the Provincial Lowest Effect Level (LEL) or the Canada soil guidelines for petroleum hydrocarbons by "◘". For the toxicity column, sites that had multiple endpoints exhibiting major toxicological effects were indicated by "■"; sites with multiple endpoints exhibiting minor toxicological effect and/or one endpoint exhibiting a major effect by "◘". For the benthos alteration column, sites determined from the BEAST analyses as being different or very different from reference were indicated by "■"; sites determined as possibly different from reference by "◘". Sites with no sediment quality guideline exceedences, benthic communities that were equivalent to reference conditions, and sites with no toxicity or minor toxicity for a maximum of one endpoint were indicated by "☐". Some sites that were possibly different than reference according to the BEAST benthic community assessment were not recommended for further action because the abundance or taxa richness indicated that these sites were not impaired.

Bellevue Marine Park

A total of 13 sites were sampled in BMP from 2002 to 2006 (Table 11a). All sites had exceedences of LELs for several metals, 54% of sites exceeded the LEL for total PAHs and 38% of sites exceeded the soil guidelines for F3 and F4 fractions of PHCs. Three of the 13 sites (6986, 6991 and 6992) were sampled in 2002 and 2006 and 2 (6986, 6991) showed different assessment outcomes between years (Table 11a). In 2002, sites 6986 and 6991 showed strong evidence of toxicity, with low chironomid survival (41 – 52%), reduced mayfly growth (-0.07 – 0.38 mg dw per individual) and slightly depressed amphipod survival (75 – 77%) (Milani and Grapentine 2006). These 2002 sites have a "◘" or "■" in the toxicity column and the overall assessment outcome was *determine reason(s) for sediment toxicity*. In 2006, mayfly growth was reduced by less than that observed in 2002 (0.52 – 0.63 mg dw per individual) and chironomid survival was much higher (80 – 92%). The amphipod test was not conducted in 2006, so results could not be compared. With minor toxicity for only one endpoint (mayfly growth) evident in 2006, the sites have a "☐" in the toxicity column and the assessment outcome was *no further actions needed*. The discrepancy in toxicity results between years likely reflects small scale heterogeneity in the area as sites were 8.5 and 5 m apart, respectively. The outcome for all remaining sites in BMP was *no further actions needed* or management action not required.

East Bellevue Marine Park

A total of 23 sites were sampled in EBMP from 2006 to 2010 (Table 11b). Almost all sites had exceedences of LELs for several metals and total PAHs while 35% of sites had F3 or F4 PHC concentrations that exceeded soil guidelines. Site EC64 was sampled in 2006 and 2008. Toxicity was evident in both years, but was more severe in 2008. The benthic community was degraded in 2006 (Milani and Grapentine 2009) but not in 2008 (Milani and Grapentine 2010). As a result, the assessment outcomes for EC64 in 2006 was *management actions required* and in 2008 was *determine reason(s) for sediment toxicity*. Although the different results between years likely reflects small scale heterogeneity (sites were 7 m apart between sampling years), the most conservative outcome of the two was considered for this site (*management actions required*). Six other sites also indicated management *actions required* (Table 11b). For five of these six sites, this outcome was based on a benthic community that was considered possibly different than reference (as well as toxicity), although some sites had benthic communities that were more impaired than others (e.g., 3 taxa present at CS10 (Milani and Grapentine 2010) vs. 9 taxa at EC35). The bulk of the outcome for remaining sites was to determine reasons for toxicity which has proven to be difficult (see Section 3.4). The location of sites requiring management actions in EBMP is shown in Fig. 14a.

Lake George Channel

A total of 18 sites were sampled in LGC, and 2 (EC39 and DBCR1) indicated *management actions required* (Table 11c). Sites EC39 and DBCR1 are located in the lower part of the channel (halfway from Partridge Point to Bell Point), where very soft sediment deposits were found. The bulk of the remaining outcomes were *no further actions needed* or to *determine reason(s) for toxicity*. Sites 170 and 6901 were sampled multiple times (2002, 2006 and 2009) and discrepancies were observed between outcomes which were likely due differences in actual sampling locations. Site 6901 was between 6 to 13 m apart between sampling periods. The outcome for the 2006 and 2009 sampling years was *no further actions needed* and the outcome for the first sampling event in 2002 was *determine(s) reasons for benthos alteration*. As there was no strong evidence of benthic community impairment for site 6901 sampled in 2002 (the benthic community was categorized as "possibly different" than reference), the final outcome for site 6901 would be *no further actions needed*. Site 170 was between 13 to 22 m apart between sampling years and there were clear differences in sediment physical characteristics between sampling years. The outcome was *determine reason(s) for benthos alteration and sediment toxicity* for 2002 and 2006. Since toxicity was not assessed in 2009 at site 170, the outcome was *determine reason(s) for benthos alteration*. Contaminant concentrations were low at site 170 thus management actions would not be required. The location of sites requiring management actions in LGC is shown in Fig. 14b.

Overall Outcomes for the St. Marys River

A summary comparison of the Sediment Decision-Making Framework assessment outcomes for BMP, EBMP and LGC is provided in Table 12. Sites fell into one of five assessment outcomes:

a) Management actions required;
b) Determine reason(s) for toxicity;
c) Determine reason(s) for benthos alteration;
d) Determine reason(s) for benthos alteration and sediment toxicity, and;
e) No further actions needed.

East Belleview Marine Park was the most impacted area with 7 of the 23 sites requiring management actions compared to 2 of the 18 sites for LGC and 0 of the 13 sites for BMP (Table 12). Toxicity was most prevalent in EBMP with 8 sites (35%) requiring the reason(s) for toxicity to be determined compared to 6 sites (33%) in LGC and 2 sites (15%) in BMP. Benthic communities in EBMP and the lower part of LGC were similarly impacted, with 3 sites in each area requiring the reason for benthos alteration to be determined and 1 site in each area requiring the reason for benthos alteration as well as toxicity to be determined. Bellevue Marine Park was the least impacted area, with no further actions needed for 11 of the 13 sites.

4 CONCLUSIONS

Multiple years of sediment sampling by Environment Canada from 2002 to 2010 in the St. Marys River included the analysis of sediment physico-chemical properties, benthic invertebrate communities and toxicity. Sampling focused mainly on three depositional areas of the river: Bellevue Marine Park, East Bellevue Marine Park and Lake George Channel.

Sediment Physico-Chemical Properties

- East Bellevue Marine Park and lower Lake George Channel consist mainly of fine grain sediments (silts and clays) which are associated with contaminants. Sediments in Bellevue Marine Park consisted of either silty sand or silty clay.
- Generally all areas were enriched with organic matter with total organic carbon generally high throughout.
- Trace metal concentrations were mostly between low and high guidelines except for iron which exceeded high guidelines.
- PAHs were elevated compared to local reference sites and low guidelines and were most elevated in East Bellevue Marine Park; most concentrations were below 20 mg/kg. Examination of PAHs patterns and ratios indicated that the source was likely combustion-derived.
- Petroleum hydrocarbons were similarly elevated in the three depositional areas compared to local reference sites. There was the presence of heavy petroleum hydrocarbons in the sediment.
- Oil and grease was elevated compared to local reference sites. Levels were highest in East Bellevue Marine Park.
- PCBs were low or not detected.

Benthic Invertebrate Community

Benthic communities were degraded at some sites in East Bellevue Marine Park and Lake George Channel due primarily to increased abundance of pollution tolerant species (worms and chironomids) compared to reference. Benthic communities in the lower half of Lake George Channel were similar to those in East Bellevue Marine Park. The increased abundance of pollution tolerant species in EBMP and LGC, and low abundance of pollution-intolerant species, suggest that the ecology of parts of these areas continues to be impacted by the physico-chemical conditions of the sediment to which these organisms are exposed.

Sediment Toxicity

Toxicity was evident in all three areas of the river, but was most severe in East Bellevue Marine Park and parts of Lake George Channel. Examination of toxicity-contaminant relationships showed varied results between studies and no contaminant could be identified as the singular cause of toxicity.

Sediment Decision-Making Framework

The sediment decision-making framework was applied to St. Marys River sites from 2002 to 2010. Although contaminants were elevated in Bellevue Marine Park, this area was the least biologically impacted and does not require sediment management. The area East of Bellevue Marine Park and lower parts of Lake George Channel showed impacts, with toxicity and impaired benthic communities evident. Management actions are required for 7 sites in East Bellevue Marine Park and 2 sites in Lake George Channel.

5 RECOMMENDATIONS

Sampling coverage is sufficient for the purposes of advancing the sediment management plan for the St. Marys River and it is recommended that no further sampling for benthic invertebrate community and toxicity assessment is required at this time.

6 REFERENCES

APHA/WEF/AWWA. 2005. Oil and Grease, Standard Methods for the Examination of Water and Wastewater, 21st Edition. Published by the American Public Health Association, Water Environment Federation, and the American Water Works Association.

Bedard, D., and S. Petro. 1997. Laboratory sediment bioassay report on St. Marys River sediments 1992 and 1995. Ontario Ministry of Environment and Energy. October 1997. 59 pp.

Belbin, L. 1993. PATN, pattern analysis package. Division of Wildlife and Ecology, CSIRO, Canberra, Australia.

Biberhofer, J. (Hans). St. Marys River sediment investigations. Unpublished data. Environment Canada, Burlington, Ontario.

Blatant Fabrications Pty Ltd. 2001. PATN Version 3.03. December 2, 2004.

Burniston, D. 2007. Sediment investigations in the Lake George Channel of the St. Marys River. Interim Report. Water Quality Monitoring and Surveillance Office. Environment Canada, Burlington, Ontario. Science and Technology Branch Report No. 07-851.

Cancilla, D. (ed.) 1994. Manual of analytical methods. Vol. 1. National Laboratory for Environmental Testing, Canada Centre for Inland Waters, Environment Canada, Burlington, Ontario.

CCME. 2008. Canada-wide standards for petroleum hydrocarbons (PHCs) in soil. Endorsed by CCME Council of Ministers, April 30-May 1, 2001, Winnipeg, MN. Table 1 Revised January 2008. 8 pp. http://www.ccme.ca/ourwork/soil.html?category_id=43

Duncan, G.A., and G.G. LaHaie. 1979. Size analysis procedures used in the Sedimentology laboratory. Unpublished Report, Hydraulics Division, National Water Research Institute, Burlington, Ontario, Canada, unpublished data.

Environment Canada. Sediment physico-chemical characteristics of Great Lakes reference sites. Unpublished data.

EC/MOE (Environment Canada/ (Ontario)Ministry of the Environment). 2007. Canada-Ontario decision-making framework for assessment of Great Lakes contaminated sediment. Prepared by P. Chapman with the COA Sediment Task Group on behalf of Environment Canada and the Ontario Ministry of the Environment. June 2007. ISBN 978-0-662-46147-0.

EC (Environment Canada). 2008. 2008-09 NLET (National Laboratory for Environmental Testing) Schedule of Services. Environment Canada, Burlington, Ontario.

Fletcher, R., P. Welsh, and T. Fletcher. 2008. Guidelines for identifying, assessing and managing contaminated sediment in Ontario: an integrated approach. Ontario Ministry of the Environment. PIBS 6658e. May 2008.

Headley, J.C., C. Akre, F.M. Conly, K.M. Peru and L.C. Dickson. 2001. Preliminary characterization and source assessment of PAHs in tributary sediments of the Athabasca River, Canada. Environ. Forensics 2, 335-345.

Manly, B.F.J. 1991. Randomization and Monte Carlo methods in biology. Chapman & Hall, London. 281 p. In: Belbin, L. 1993. PATN, pattern analysis package. Division of Wildlife and Ecology, CSIRO, Canberra, Australia.

Milani, D, and L. Grapentine. 2006. The application of BEAST sediment quality guidelines to the St. Marys River Area of Concern. Environment Canada, Burlington, Ontario. National Water Research Institute No. 06-415.

Milani, D, and L. Grapentine. 2009. Biological assessment of sediment collected from the St. Marys River in 2006: Application of the sediment decision-making framework. Environment Canada, Burlington, Ontario. Water Science Technology Directorate Contribution No. 09-513.

Milani, D, and L. Grapentine. 2010. St. Marys River Biological Assessment 2008: East of Bellevue Park and Lake George Channel. Environment Canada, Burlington, Ontario. Water Science Technology Directorate Contribution No. 10-069.

Minitab Inc. 2007. Minitab 15, Version 15.1.1.0.

Mount, D., L. Heinis, T. Highland, J.R. Hockett, C. Jenson, T.J. Norberg-King. 2009. Are PAHs the Right Metric for Assessing Toxicity Related to Oils, Tars, Creosote, and Similar Contaminants in Sediments? Society of Environmental Toxicology and Chemistry 30th Annual Meeting, New Orleans, USA.

Page, D.S., P.D. Boehm, G.S. Douglas, A.E. Bence, W.A. Burns, and P.J. Mankiewicz. 1999. Pyrogenic polycyclic aromatic hydrocarbons in sediments record past human activity: A case study in Prince William Sound, Alaska. Marine Pollution Bulletin 38: 247-260.

Pies C., T. A. Ternes, and T. Hofmann. 2008. Identifying sources of polycyclic aromatic hydrocarbons (PAHs) I soils: distinguishing point and non-point sources using an extended PAH spectrum and *n*-alkanes. J Soils Sediments 8: 312-322.

Reynoldson TB, KE Day, C Clark, and D Milani.1994, Effect of indigenous animals on chronic end points in freshwater sediment toxicity tests. Environ. Toxicol. Chem. 13: 973-977.

Reynoldson T. B., R.C. Bailey, K.E. Day and R.H. Norris. 1995. Biological guidelines for freshwater sediment based on benthic assessment of sediment (the BEAST) using a multivariate approach for predicting biological state. Aust. J. Ecol. 20: 198-219.

Reynoldson, T.B. and K.E. Day. 1998. Biological guidelines for the assessment of sediment quality in the Laurentian Great Lakes. National Water Research Institute, Burlington, Ontario, Canada. NWRI Report No. 98-232.

Reynoldson, T.B., K.E. Day, and T. Pascoe. 2000. The development of the BEAST: a predictive approach for assessing sediment quality in the North American Great Lakes. Pp. 165 – 180 in Wright, J.F., D.W. Sutcliffe, and M.T. Furse (eds.), Assessing the biological quality of fresh waters: RIVPACS and other techniques. Freshwater Biological Association, UK.

Rhodes, Spencer, A. Farwell, L. M. Hewitt, M. MacKinnonc, D.G. Dixon. 2005. The effects of dimethylated and alkylated polycyclic aromatic hydrocarbons on the embryonic development of the Japanese medaka. Ecotoxicology and Environmental Safety 60 (2005) 247–258.

Roy, P.P., and K. Roy. 2008. On Some Aspects of Variable Selection for Partial Least Squares Regression Models. QSAR Comb. Sci. 27 (3): 302 – 313.

Smits, J.E., M.E. Wayland, M.J. Miller, K. Liber, and S. Trudeau. 2000. Reproductive, immune, and physiological end points in tree swallows, on reclaimed oil sands mine sites. Environ. Toxicol. Chem 19: 2951-2960.

StatSoft Inc. 2011. Statistica 10. Tulsa, OK 74104, USA.

Systat Software, Inc. 2007. SYSTAT 12 for Windows. Version 12.02.

Thorsen, W.A., W.G. Cope, and D. Shea. 2004. Bioavailability of PAHs: Effects of soot carbon and PAH source. Environ. Sci. Technol. 38: 2029-2037.

USEPA/CE (United States Environmental Protection Agency/Corps of Engineers). 1981. Procedures for handling and chemical analysis of sediment and water samples. Environmental laboratory, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, pp 3-118. EPA/CE-81-1.

USEPA. 2003. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. U.S. Environmental Protection Agency, Office of Research and Development, Washington. DC. EPA/600/R-02/013. http://www.epa.gov/nheerl/publications/files/PAHESB.pdf

USEPA. 2004. Method 9071B, Test methods for evaluating solid waste, SW-846, US EPA Office of Solid Waste, 3rd Edition. EPA-SW-846-03-03B, www.epa.gov http://www.epa.gov/epawaste/hazard/testmethods/sw846/index.htm

USEPA. 2008. Method **3540/8270-GC/MS**, Test methods for evaluating solid waste, SW-846, US EPA Office of Solid Waste, 3rd Edition. http://www.epa.gov/epawaste/hazard/testmethods/sw846/index.htm

Yunker M.B., R.W MacDonald, R. Vingarzan, R.H. Mitchell, D. Gopyette and S. Sylvestre. 2002. PAHs in the Fraser River basin: a critical appraisal of PAH ratios as indicators of PAH sources and composition. Org. Geochem 33: 489-515.

TABLES

Table 1. St. Marys River 2009-2010 sampling site positions (UTM Nad83, Zone 16), depth and visual description of sediment.

Location	Site	Year	Northing	Easting	Depth (m)	Visual Description (on site and in lab)
East Bellevue Marine Park	EC30	2009	5152727.9	707757.5	4.6	2-3 cm brown over darker brown soft mud. Hydrocarbon smell. Grease marks on sieve.
	EC31	2009	5152561.0	707754.3	5.7	Soft brown sediment. Hydrocarbon smell, oily sheen.
	EC32	2009	5152668.5	707915.8	7.5	2-3 cm light brown silt over medium brown soft sediment. Oily sheen visible. Slight hydrocarbon smell.
	EC33	2009	5152925.5	707407.6	3.0	Soft brown silty sediment
	EC34	2009	5152740.4	708011.9	5.0	2-3 cm light brown over dark brown soft mud. Oily sheen visible. Strong hydrocarbon smell. Grease marks on sieve.
	EC35	2009	5152598.4	707925.8	4.3	Silty brown soft mud with some submerged vegetation. Hydrocarbon smell. Oily.
	EC36	2009	5152587.9	708104.2	6.9	2-3cm light brown silt over darker brown soft mud. Hydrocarbon smell. Similar to EC35.
	EC37	2009	5152854.8	707669.9	3.3	Brown silty, organic mud with vegetation. Slight hydrocarbon smell.
	EC52	2010	5152495.7	708120.2	5.9	2-3cm light brown silt over sand, very flocky. Some stones present.
	EC53	2010	5152472.2	707758.6	5.1	2-3cm light brown silt over darker brown organic mud, flocky. Some vegetation present.
	EC54	2010	5152480.7	707628.9	3.0	2-3cm light brown silt over darker brown fine mud with some vegetation present.
	EC31[a]	2010	5152534.1	707779.5	5.7	2-3 cm light brown silt over darker brown fine mud
	EC64[a]	2010	5152642.9	707709.2	4.2	Fine silty mud with some vegetation present. Hydrocarbon smell, oily
Lake George Channel	170	2009	5153674.9	710712.4	3.1	Fine silt over sand with some submerged vegetation present.
	EC38	2009	5156840.6	712256.1	3.8	Silty brown soft mud
	EC39	2009	5157321.1	712580.9	4.4	Silty brown soft mud
	6901	2009	5157734.3	714253.9	2.0	Silty brown mud with vegetation. Organic.
	EC47	2010	5156998.6	712310.1	3.75	2-3 cm light brown mud over dark mud, organic. Flocky matter.
	EC48	2010	5157220.3	712496.3	5.3	Soft silty mud. Flocky matter.
	EC49	2010	5157405.9	712776.2	3.3	2-3 cm medium brown silt over dark brown silty mud with lots of vegetation.
	EC50	2010	5157527.7	712919.1	3.5	Soft fine silty mud with lots of vegetation.
	EC51	2010	5157560.6	713168.7	4.5	Very fine silty mud with a little bit of vegetation on top.
Upstream Reference	EC56	2010	5151609.6	694565.9	4.2	2-3cm silt over sticky clay. Some wood debris and pine needles present.
	EC57	2010	5151788.9	694533.7	4.6	Silt over fine sandy clay, slightly sticky. Some bark present.
	52-479	2010	5151998.6	694557.2	3.8	Silt over sticky clay. Some wood debris and pine needles present.
	6903	2010	5149314.9	694172.0	4.5	2-3 cm light silt over sandy clay.

[a] confirmation site - oil and grease determination only

Table 2. Environmental variables measured at St. Marys River sites for 2009-2010. Variables were measured in both years unless otherwise noted.

Field	Water	Sediment
Northing	Alkalinity	Suite of Metals
Easting	Conductivity	Major Oxides
Site depth	Dissolved Oxygen	Total Kjeldahl Nitrogen
	pH	Total Phosphorus
	Temperature	Total organic Carbon
	Total Kjeldahl Nitrogen	Loss on Ignition
	Total Phosphorus	% Sand, Silt, Clay, Gravel
	Ammonia	PAHs (parent compounds)
	Nitrates/Nitrites	Alkylated PAHs (2010 only)
	Hardness (2010 only)	Petroleum Hydrocarbons
		Oil and Grease
		Polychlorinated Biphenyls

Table 3. Characteristics of overlying water at St. Marys River sites for 2009-2010. Values are in mg/L unless otherwise noted.

Site	Year	Alkalinity	Cond. (µS/cm)	Dissolved O_2	Hardness	NH_3	NO_3/NO_2	TKN	pH	Temp (°C)	Total P µg/L
EC30	2009	43.5	96	10.2	-	0.038	0.304	0.303	7.9	12.5	0.0061
EC31	2009	42.4	97	10.2	-	0.028	0.304	0.165	8.0	12.5	0.0058
EC32	2009	43.2	96	10.3	-	0.015	0.299	0.128	8.0	12.6	0.0065
EC33	2009	43.7	96	10.4	-	0.068	0.278	0.293	8.0	11.9	0.0073
EC34	2009	44.2	96	10.3	-	0.024	0.310	0.141	8.0	12.6	0.0055
EC35	2009	43.3	98	10.1	-	0.022	0.292	0.143	7.9	12.5	0.0060
EC36	2009	43.0	96	10.3	-	0.026	0.302	0.161	8.0	12.6	0.0056
EC37	2009	41.9	96	10.0	-	0.021	0.295	0.130	7.9	11.9	0.0049
EC52	2010	42.0	108	10.3	46.0	0.026	0.297	0.266	7.9	10.9	0.0082
EC53	2010	41.9	108	10.3	46.0	0.021	0.299	0.146	7.9	10.8	0.0098
EC54	2010	41.6	109	10.3	46.3	0.020	0.301	0.142	7.9	10.5	0.0151
170	2009	42.5	98	10.4	-	0.017	0.303	0.139	7.9	11.6	0.0065
EC38	2009	42.2	96	10.2	-	0.025	0.305	0.145	7.9	12.3	0.0054
EC39	2009	42.5	97	10.3	-	0.021	0.307	0.132	7.9	12.3	0.0065
6901	2009	42.3	95	10.2	-	0.018	0.301	0.150	7.9	12.2	0.0058
EC47	2010	42.8	109	10.0	46.5	0.019	0.312	0.168	7.8	11.8	0.0176
EC48	2010	42.8	109	10.1	46.7	0.017	0.314	0.188	7.8	11.8	0.0066
EC49	2010	43.1	112	10.2	47.8	0.020	0.318	0.171	7.9	11.0	0.0149
EC50	2010	42.6	111	10.2	47.5	0.019	0.310	0.205	8.0	11.0	0.0091
EC51	2010	42.4	111	10.3	47.1	0.016	0.311	0.147	8.0	11.1	0.0083
EC56	2010	41.6	105	11.0	45.5	0.012	0.289	0.109	8.0	9.1	0.0044
EC57	2010	41.7	105	11.2	45.2	0.011	0.289	0.132	8.0	9.2	0.0113
52-479	2010	41.4	104	11.1	44.8	0.011	0.285	0.129	8.0	9.1	0.0050
6903	2010	41.0	105	11.2	45.5	0.010	0.298	0.134	8.0	8.5	0.2280

Table 4. St. Marys River sediment grain size for 2009-2010.

Site	Year	% Sand	% Silt	% Clay	% Gravel
EC30	2009	1.5	66.5	31.9	0.0
EC31	2009	1.0	55.8	43.2	0.0
EC32	2009	1.0	66.5	32.6	0.0
EC33	2009	3.4	64.6	32.0	0.0
EC34	2009	1.2	68.5	30.3	0.0
EC35	2009	2.2	68.6	29.2	0.0
EC36	2009	6.0	59.1	34.9	0.0
EC37	2009	2.6	57.4	39.9	0.0
EC52	2010	71.4	28.3	0.2	0.0
EC53	2010	6.2	93.3	0.4	0.0
EC54	2010	4.3	95.4	0.3	0.0
170	2009	97.6	0.0	2.4	0.0
EC38	2009	7.2	53.0	39.7	0.0
EC39	2009	3.7	64.5	31.9	0.0
6901	2009	8.1	51.6	40.3	0.0
EC47	2010	7.7	91.8	0.5	0.0
EC48	2010	1.9	97.7	0.4	0.0
EC49	2010	3.4	96.2	0.4	0.0
EC50	2010	3.6	96.2	0.2	0.0
EC51	2010	7.3	91.9	0.7	0.0
EC56	2010	22.8	76.9	0.32	0
EC57	2010	61.1	38.8	0.07	0
52-479	2010	37.0	62.9	0.09	0
6903	2010	40.2	59.5	0.30	0

Table 5a. Sediment trace metal and nutrient concentrations (dry wt) for 2009 St. Marys River sites. Values > the provincial Sediment Quality Guideline Severe Effect Level (SEL) are indicated in red; values greater than the Lowest Effect Level (LEL) are in blue.

						East of Bellevue Park								Lake George Channel			
Parameter	Units	M.D.L.	Reference Method	LEL	SEL	EC30	EC31	EC32	EC33[a]	EC34	EC35	EC36	EC37	170	EC38	EC39	6901
Aluminum	µg/g	10	EPA 6010			11000	10000	10000	12000	9000	9000	6000	9000	2000	5000	7000	6700
Antimony	µg/g	0.5	EPA 6020			1.4	1.0	0.8	1.5	1.4	1.4	0.8	1.5	< 0.5	0.6	0.7	0.7
Arsenic	µg/g	0.5	EPA 6020	6	33	**15.4**	**9.3**	**8.2**	**10.5**	**13.1**	**12.4**	**8.8**	**11.2**	1.2	5.2	5.4	4.4
Barium	µg/g	1	EPA 6010			58	59	57	67	47	51	30	52	9	26	39	38
Beryllium	µg/g	0.2	EPA 6010			0.5	0.4	0.5	0.6	0.4	0.4	0.3	0.5	< 0.2	0.2	0.3	0.3
Bismuth	µg/g	5	EPA 6010			< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Cadmium	µg/g	0.5	EPA 6010	0.6	10	**1.2**	**1.0**	**1.1**	**1.6**	**1.2**	**0.8**	< 0.5	**1.1**	< 0.5	< 0.5	0.6	< 0.5
Calcium	µg/g	10	EPA 6010			4220	4050	4040	4233	3840	3700	2920	3940	1040	2450	3190	2830
Chromium	µg/g	1	EPA 6010	26	110	**70**	**65**	**66**	**80**	**68**	**65**	**57**	**75**	7	**34**	**50**	**31**
Cobalt	µg/g	1	EPA 6010			11	10	10	11	10	10	9	10	2	6	8	6
Copper	µg/g	1	EPA 6010	16	110	**80**	**69**	**68**	**85**	**74**	**66**	**44**	**77**	7	**34**	**49**	**37**
Iron	µg/g	10	EPA 6010	2%	4%	**6.1**	**5.4**	**5.8**	**6.0**	**6.3**	**5.9**	**6.0**	**6.2**	0.6	**3.6**	**4.7**	**2.5**
Lead	µg/g	5	EPA 6010	31	250	**106**	**73**	**67**	**164**	**85**	**82**	**45**	**104**	6	**41**	**43**	28
Magnesium	µg/g	10	EPA 6010			4380	4080	4110	4443	3840	3630	2630	3750	810	1960	2790	2800
Manganese	µg/g	1	EPA 6010	460	1100	**597**	**505**	**538**	**588**	**608**	**573**	**559**	**582**	54	353	439	226
Mercury	µg/g	0.005	EPA 7471A	0.2	2	0.181	0.148	0.117	**0.316**	0.15	0.15	0.10	**0.238**	0.021	0.119	0.176	0.083
Molybdenum	µg/g	1	EPA 6010			3.000	2.000	3.000	1.500	3.000	3.000	2.000	2.000	< 1	< 1	2.000	< 1
Nickel	µg/g	1	EPA 6010	16	75	**30**	**25**	**26**	**30**	**29**	**27**	**22**	**24**	4	16	**19**	14
Phosphorus	µg/g	5	EPA 6010			612	674	701	705	559	590	576	676	217	514	628	544
Potassium	µg/g	30	EPA 6010			1140	1090	1100	1125	1020	1110	710	1040	210	540	810	850
Silicon	µg/g	1	EPA 6010			196	214	214	208	175	195	179	196	180	173	177	145
Silver	µg/g	0.2	EPA 6010			0.5	0.4	0.3	0.7	0.4	0.4	< 0.2	0.6	< 0.2	0.2	0.5	< 0.2
Sodium	µg/g	20	EPA 6010			200	180	180	185	170	200	140	160	40	100	140	150
Strontium	µg/g	1	EPA 6010			14	15	16	21	14	13	12	14	3	8	11	10
Tin	µg/g	10	EPA 6010			< 10	< 10	< 10	10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Titanium	µg/g	1	EPA 6010			503	514	537	556	496	518	439	447	231	378	479	414
Vanadium	µg/g	1	EPA 6010			34	32	33	36	32	31	26	30	10	19	24	24
Yttrium	µg/g	0.5	EPA 6010			8.2	7.9	8.1	8.8	7.7	7.5	6.8	7.8	2.7	6.2	7.2	6.3
Zinc	µg/g	1	EPA 6010	120	820	**354**	**275**	**253**	**456**	**322**	**285**	**176**	**343**	26	**140**	**176**	107
Zirconium	µg/g	0.1	EPA 6010			0.1	< 0.1	0.4	< 0.1	< 0.1	< 0.1	0.6	< 0.1	1.1	< 0.1	0.4	0.3
Aluminum (Al2O3)	%	0.01	IN-HOUSE			6.73	6.27	7.31	7.40	6.4	6.54	7.65	7.33	3.87	6.58	6.2	8.11
Barium (BaO)	%	0.001	IN-HOUSE			0.030	0.030	0.040	0.03	0.03	0.03	0.06	0.04	0.030	0.04	0.04	0.060
Calcium (CaO)	%	0.01	IN-HOUSE			< 0.01	< 0.01	0.59	< 0.01	< 0.01	0.78	9.71	1.36	< 0.01	0.87	0.80	0.77
Chromium (Cr2O3)	%	0.01	IN-HOUSE			< 0.01	< 0.01	0.06	0.05	< 0.01	< 0.01	0.06	0.06	< 0.01	0.06	0.03	0.03
Iron (Fe2O3)	%	0.05	IN-HOUSE			6.58	5.79	7.55	6.92	6.98	5.25	8.45	7.82	0.93	4.78	5.38	4.07
Magnesium (MgO)	%	0.01	IN-HOUSE			0.58	0.41	1.09	0.68	0.50	0.80	1.29	1.11	< 0.01	0.63	0.70	0.55
Manganese (MnO)	%	0.01	IN-HOUSE			0.06	0.05	0.46	0.07	0.06	0.06	0.12	0.08	0.01	0.05	0.05	0.05
Phosphorus (P2O5)	%	0.03	IN-HOUSE			< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Potasium (K20)	%	0.01	IN-HOUSE			1.11	1.12	1.65	1.19	1.08	1.25	1.79	1.52	1.04	1.60	1.41	1.83
Silica (SiO2)	%	0.01	IN-HOUSE			37.7	38.1	44.7	38	38.5	39.6	53.7	43.2	49	49	43.9	55.4
Sodium (Na2O)	%	0.01	IN-HOUSE			< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Titanium (TiO2)	%	0.01	IN-HOUSE			0.35	0.35	0.42	0.39	0.35	0.35	0.4	0.4	0.13	0.32	0.33	0.43
Loss on Ignition	%	0.05	IN-HOUSE			15.7	13.5	11.2	15.7	14	14.4	10.8	14.5	1.61	7.63	10.7	8.81
Whole Rock Total	%		IN-HOUSE			68.8	65.6	75.1	70.7	67.9	69.0	94.0	77.4	56.6	71.6	69.5	80
Total Organic Carbon	% by wt	0.1	LECO	1	10	**8.0**	**6.8**	**6.4**	**7.3**	**6.7**	**7.0**	**4.8**	**6.5**	0.6	**3.9**	**4.8**	**4.6**
Total Kjeldahl Nitrogen	µg/g	0.05	EPA 351.2	550	4800	**4300**	**3540**	**3330**	**4310**	**3440**	**3010**	**2080**	**2870**	527	**1350**	**2640**	**3280**
Phosphorus-Total	µg/g	0.01	EPA 365.4	600	2000	**695**	**707**	**734**	**758**	**697**	**621**	**602**	**629**	233	552	**743**	**694**

[a] mean of three field replicates; MDL = Method Detection Limit

Table 5b. Sediment trace metal and nutrient concentrations (dry wt) for 2010 St. Marys River sites. Values > the provincial Sediment Quality Guideline Severe Effect Level (SEL) are indicated in red; values greater than the Lowest Effect Level (LEL) are in blue.

			Reference			Upstream Reference				East of Belleview Park					Lake George Channel				
Parameter	Units	M.D.L.	Method	LEL	SEL	EC56	EC57	52-479	6903	EC52[a]	EC53	EC54	EC31	EC64	EC47	EC48	EC49	EC50	EC51
Aluminum	µg/g	10	EPA 6010			2870	2540	2930	3430	2550	5620	6590	8360	9770	5820	5420	6790	7170	5320
Antimony	µg/g	0.5	EPA 6020			< 0.5	< 0.5	< 0.5	< 0.5	0.9	0.8	0.8	0.8	1.2	0.6	0.5	< 0.5	0.7	1.3
Arsenic	µg/g	0.5	EPA 6020	6	33	1.7	1.5	2.3	2.6	4.1	**9.2**	**8.5**	**8.9**	**15.1**	5.1	4.7	4.7	**6.6**	**9.1**
Barium	µg/g	1	EPA 6010			17	15	17	18	13	32	44	51	59	51	44	49	50	33
Beryllium	µg/g	0.2	EPA 6010			< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.3	0.3	0.4	0.5	0.3	0.3	0.3	0.4	0.3
Bismuth	µg/g	5	EPA 6010			< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Cadmium	µg/g	0.5	EPA 6010	0.6	10	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.6	**0.8**	**1.2**	**1.3**	**1.1**	0.8	0.7	**0.9**	0.8
Calcium	µg/g	10	EPA 6010			2170	2040	2330	2210	1770	3410	3970	4330	4470	3260	3190	3900	3800	3040
Chromium	µg/g	1	EPA 6010	26	110	9	8	9	12	**36**	**60**	**58**	**63**	**75**	**42**	**46**	**42**	**48**	**50**
Cobalt	µg/g	1	EPA 6010			3	2	3	5	8	18	17	17	20	11	13	12	13	16
Copper	µg/g	1	EPA 6010	16	110	12	10	14	14	15	**49**	**53**	**66**	**83**	**52**	**52**	**50**	**61**	**55**
Iron	µg/g	10	EPA 6010	2%	4%	6550	5780	6370	11800	**29900**	**65900**	**51800**	**58100**	**64700**	**35200**	**41600**	**35200**	**40100**	**55500**
Lead	µg/g	5	EPA 6010	31	250	9	8	8	12	23	**57**	**56**	**70**	**106**	**49**	**46**	**42**	**54**	**76**
Magnesium	µg/g	10	EPA 6010			1240	1090	1240	1730	1213	2780	3260	3740	4500	2790	2790	3390	3470	2600
Manganese	µg/g	1	EPA 6010	460	1100	62	57	63	83	232	**579**	460	**491**	**592**	301	378	325	376	**550**
Mercury	µg/g	0.005	EPA 7471A	0.2	2	0.02	0.01	0.02	0.014	0.092	0.128	0.130	0.183	0.201	0.173	0.14	0.171	0.180	**0.228**
Molybdenum	µg/g	1	EPA 6010			< 1	< 1	< 1	< 1	< 1	2.000	2.000	2.000	3.000	< 1	1.000	< 1	1	1.000
Nickel	µg/g	1	EPA 6010	16	75	6	5	6	8	11	**25**	**23**	**25**	**32**	**18**	**18**	**18**	**22**	**22**
Phosphorus	µg/g	5	EPA 6010			312	291	304	381	354	558	578	613	586	567	606	644	596	575
Potassium	µg/g	30	EPA 6010			330	280	320	360	297	680	820	960	1100	710	710	1050	940	670
Silicon	µg/g	1	EPA 6010			98	100	110	116	138	107	96	258	102	136	148	150	151	155
Silver	µg/g	0.2	EPA 6010			< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.3	0.3	0.3	0.5	0.7	0.5	0.3	0.5	0.6
Sodium	µg/g	20	EPA 6010			690	680	560	650	630	840	820	750	840	710	740	810	760	780
Strontium	µg/g	1	EPA 6010			6	6	7	6	6	10	12	13	14	10	10	12	12	10
Tin	µg/g	10	EPA 6010			< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Titanium	µg/g	1	EPA 6010			289	269	288	379	236	383	394	502	499	343	360	397	391	352
Vanadium	µg/g	1	EPA 6010			13	11	12	23	14	25	28	30	35	22	22	26	27	23
Yttrium	µg/g	0.5	EPA 6010			4.4	4.1	4.1	5.6	5.0	7.2	7.6	8.4	9.3	7.4	7.5	8.0	8.3	7.2
Zinc	µg/g	1	EPA 6010	120	820	25	21	29	33	66	**192**	**202**	**243**	**365**	**181**	**170**	**161**	**199**	**227**
Zirconium	µg/g	0.1	EPA 6010			1.7	1.8	1.8	2.0	1.4	1.9	2.0	2.9	2.6	2.2	2.3	2.2	2.2	1.5
Aluminum (Al2O3)	%	0.2	IN-HOUSE			8.0	7.8	7.7	7.9	7.0	7.8	8.3	6.8	9.0	8.7	8.8	8.1	8.9	8.4
Barium (BaO)	%	0.01	IN-HOUSE			0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.04	0.05	0.06	0.06	0.05	0.05	0.06
Calcium (CaO)	%	0.3	IN-HOUSE			1.50	1.40	1.40	1.40	1.0	1.4	1.5	1.20	1.50	1.5	1.5	1.4	1.5	1.4
Chromium (Cr2O3)	%	0.03	IN-HOUSE			< 0.03	< 0.03	< 0.03	< 0.03	0.05	0.03	0.03	< 0.03	< 0.03	< 0.03	0.03	< 0.03	< 0.03	0.03
Iron (Fe2O3)	%	0.1	IN-HOUSE			2.6	1.8	1.7	2.5	5.2	8.7	7.7	6.6	9.2	6.1	6.9	5.4	6.6	8.8
Magnesium (MgO)	%	0.2	IN-HOUSE			0.7	0.6	0.5	0.7	0.5	1.0	1.0	0.9	1.2	1.0	0.9	1.0	1.0	0.9
Manganese (MnO)	%	0.01	IN-HOUSE			0.01	0.01	0.01	0.02	0.03	0.07	0.06	0.05	0.07	0.04	0.05	0.04	0.05	0.07
Phosphorus (P2O5)	%	2	IN-HOUSE			< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Potasium (K20)	%	1	IN-HOUSE			2.3	2.1	2.1	2.2	2.3	1.8	1.8	1.3	1.8	2	2	2	2	2.1
Silica (SiO2)	%	0.5	IN-HOUSE			64.8	69.7	60.9	60.8	59.1	51.3	53.4	41.2	51	53.0	58.3	51.2	54.9	56.3
Sodium (Na2O)	%	3	IN-HOUSE			< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3
Titanium (TiO2)	%	0.1	IN-HOUSE			0.4	0.4	0.4	0.4	0.3	0.4	0.5	0.4	0.5	0.5	0.5	0.4	0.5	0.5
Loss on Ignition	%	0.05	IN-HOUSE			4.23	3.57	5.36	3.29	4.76	13.9	13.9	13.5	15.1	10.2	10.4	11.9	12.6	10.7
Whole Rock Total	%		IN-HOUSE			87.0	89.5	82.2	82	81.9	88.1	90.0	73.4	91.2	84.7	91.2	82.9	89.9	91.0
Total Organic Carbon	% by wt	0.1	LECO	1	10	**1.7**	**1.3**	**1.8**	0.9	**3.0**	**6.2**	**6.2**	**6.6**	**7.1**	**4.2**	**5.1**	**5.3**	**5.2**	**5.5**
Total Kjeldahl Nitrogen	µg/g	0.05	EPA 351.2	550	4800	**1210**	**1080**	**1590**	**932**	**685**	**3110**	**4020**	**3620**	**3410**	**3130**	**2660**	**3690**	**3880**	**2900**
Phosphorus-Total	µg/g	0.01	EPA 365.4	600	2000	317	316	286	335	450	**684**	**700**	**721**	**613**	**658**	**699**	**702**	**626**	**794**

[a] mean of three field replicates; MDL = Method Detection Limit

Table 6a. Sediment petroleum hydrocarbon, oil and grease and PAH concentrations (mg/kg dw) in East Bellevue Marine Park for 2009-2010. Values below method detection limits are indicated by "<". [Detection limits are provided in Appendix A, Table A7-A8.] Values in red exceed sediment guidelines.

Site	Guide-line	EC52[a]	EC53	EC54	EC64	EC31	EC31	EC30	EC32	EC33[a]	EC34	EC35	EC36	EC37
Year Sampled		2010	2010	2010	2010	2010	2009	2009	2009	2009	2009	2009	2009	2009
Aggregate Organics														
Oil and Grease, Total		2310	8570	10600	15100	9500	8270	8690	8250	12100	14000	6650	4470	2340
Volatile Organic Compounds														
Benzene		<0.050	<0.15	<0.15	<0.15	<0.15	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Ethyl Benzene		<0.050	<0.15	<0.15	<0.15	<0.15	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Toluene		<0.050	<0.15	<0.15	<0.15	<0.15	0.065	<0.050	0.085	0.05	<0.050	0.074	<0.050	0.056
o-Xylene		<0.050	<0.15	<0.15	<0.15	<0.15	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
m+p-Xylenes		<0.10	<0.30	<0.30	<0.30	<0.30	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Xylenes (Total)		<0.15	<0.34	<0.34	<0.34	<0.34	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
Hydrocarbons	**CWS[b]**													
F1 (C6-C10)	210	<5.0	<15	<15	<15	<15	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
F1-BTEX		<5.0	<15	<15	<15	<15	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
F2 (C10-C16)	150	13.3	55	41	95	<40	<20	<40	<10	<30	<30	75	<30	111
F2-Naphth		12.5	53	40	94	<40	<20	<40	<10	<30	<30	73	<30	110
F3 (C16-C34)	1300	397	1760	1560	3260	1610	1030	1340	430	1453	930	2000	740	2580
F3-PAH		385	1750	1550	3250	1600	1020	1320	416	1433	920	1980	720	2550
F4 (C34-C50)	5600	180	1460	1390	3150	1370	970	1100	355	960	830	1660	630	1600
F4G-SG (GHH-Silica)		620	3400	3300	5700	3300	2650	2980	3110	4083	1800	2980	2170	2080
Total Hydrocarbons (C6-C50)		590	3280	2990	6510	2980	2000	2440	785	2413	1760	3740	1370	4290
Chrom. to baseline at nC50		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Polycyclic Aromatic Hydrocarbons	**LEL[c]**													
Acenaphthene		0.25	0.22	0.14	0.35	0.14	0.12	0.17	0.12	0.12	0.14	0.23	0.26	0.18
Acenaphthylene		0.47	0.47	0.40	0.48	0.35	0.42	0.50	0.43	0.80	0.47	0.51	0.52	0.98
Anthracene	0.22	0.91	0.65	0.49	0.55	0.47	0.41	0.49	0.42	0.56	0.43	0.54	0.60	0.89
Benz(a)anthracene	0.32	2.22	1.90	1.43	1.64	1.41	1.61	2.06	1.57	2.37	1.70	2.14	2.20	3.80
Benzo(a)pyrene	0.37	1.42	1.35	1.04	1.08	0.96	1.75	2.20	1.69	2.59	1.81	2.15	2.24	3.73
Benzo(b&j)fluoranthene		2.20	2.24	1.82	2.16	1.79	2.18	2.63	2.06	2.95	2.16	2.62	2.32	4.34
Benzo(e)pyrene		1.04	1.25	0.90	0.94	0.84	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	0.17	0.98	1.21	0.96	1.11	0.92	1.19	1.46	1.17	1.78	1.23	1.41	1.32	2.16
Benzo(k)fluoranthene	0.24	0.82	0.77	0.63	0.58	0.54	1.03	1.34	1.02	1.78	1.05	1.26	1.46	2.20
Chrysene	0.34	2.78	2.56	2.01	2.36	2.01	1.56	2.02	1.49	2.34	1.65	1.98	1.99	3.39
Dibenz(a,h)anthracene	0.06	0.32	0.35	0.30	0.33	0.29	0.22	0.27	0.22	0.37	0.23	0.27	0.28	0.53
Fluoranthene	0.75	3.73	3.21	2.39	2.96	2.40	2.44	3.08	2.36	3.16	2.57	3.34	3.28	5.11
Fluorene	0.19	0.34	0.29	0.22	0.32	0.22	0.17	0.21	0.19	0.19	0.20	0.27	0.28	0.33
Indeno(1,2,3-cd)pyrene	0.2	1.21	1.30	1.13	1.27	1.12	1.60	1.90	1.55	2.47	1.64	1.89	1.84	3.14
Naphthalene		5.00	5.31	3.19	2.81	3.03	1.25	1.21	1.30	1.19	1.21	2.06	2.29	1.49
Perylene		0.58	0.47	0.31	0.34	0.28	-	-	-	-	-	-	-	-
Phenanthrene	0.56	2.16	1.84	1.35	1.61	1.30	1.02	1.20	1.06	1.14	1.07	1.42	1.46	1.77
Pyrene	0.49	3.05	2.71	1.96	2.48	1.98	2.05	2.69	1.99	2.78	2.26	2.86	2.71	4.41
Acridine		0.12	0.11	0.08	0.10	0.08	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6
Biphenyl		0.12	0.146	0.127	0.136	0.115	-	-	-	-	-	-	-	-
Dibenzothiophene		0.16	0.151	0.112	0.140	0.106	-	-	-	-	-	-	-	-
Quinoline		0.02	0.040	<0.010	<0.010	<0.010	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Retene		2.51	4.26	1.19	0.975	1.48	-	-	-	-	-	-	-	-
PAHs, total (18 parent compounds)	4.0	29.47	28.08	20.66	23.37	20.04	19.02	23.43	18.64	26.56	19.82	24.95	25.05	38.45

[a] QA/QC site - mean of three box cores; [b] For fine textured, residential/parkland land use category (CCME 2008); [c] Lowest Effect Level - Fletcher et al. (2008)

Table 6b. Sediment alkylated PAH and PCB concentrations (µg/g) in East Bellevue Marine Park for 2009-2010. Values below method detection limits are indicated by "<". [Detection limits are provided in Appendix A, Table A7-A8.] Values in red exceed sediment guidelines.

Site	Guide-line	EC52[a]	EC53	EC54	EC64	EC31	EC31	EC30	EC32	EC33[a]	EC34	EC35	EC36	EC37
Year Sampled		2010	2010	2010	2010	2010	2009	2009	2009	2009	2009	2009	2009	2009
Alkylated PAHs														
1-Methylnaphthalene		0.21	0.279	0.202	0.222	0.201	<0.10	<0.10	<0.10	0.11	<0.10	0.16	0.18	0.14
2-Methylnaphthalene		0.51	0.657	0.432	0.482	0.431	0.18	0.19	0.20	0.19	0.20	0.29	0.30	0.28
C2 sub'd B(a)A/chrysene		0.83	1.03	0.731	0.935	0.739	-	-	-	-	-	-	-	-
C2 Benzofluoranthenes/Benzopyrenes		0.53	0.560	0.368	0.378	0.331	-	-	-	-	-	-	-	-
C2 Biphenyls		0.07	0.082	0.071	0.087	0.062	-	-	-	-	-	-	-	-
C2 Dibenzothiophenes		0.30	0.498	0.323	0.537	0.274	-	-	-	-	-	-	-	-
C2 Fluoranthenes/Pyrenes		0.88	0.935	0.713	0.824	0.657	-	-	-	-	-	-	-	-
C2 Fluorenes		0.22	0.271	0.208	0.247	0.183	-	-	-	-	-	-	-	-
C2 Naphthalenes		0.94	1.26	0.980	1.13	0.951	-	-	-	-	-	-	-	-
C2 Phenanthrenes/Anthracenes		1.31	1.49	1.05	1.37	0.989	-	-	-	-	-	-	-	-
C3 Benzanthracenes/Chrysenes		0.35	0.393	0.488	0.549	0.463	-	-	-	-	-	-	-	-
C3 Dibenzothiophenes		0.39	0.702	0.293	0.940	0.386	-	-	-	-	-	-	-	-
C3 Fluoranthenes/Pyrenes		0.54	0.706	0.486	0.603	0.462	-	-	-	-	-	-	-	-
C3 Fluorenes		0.33	0.414	0.387	0.557	0.388	-	-	-	-	-	-	-	-
C3 Naphthalenes		0.73	0.778	0.605	0.740	0.583	-	-	-	-	-	-	-	-
C3 Phenanthrenes/Anthracenes		1.26	1.78	1.08	1.72	1.03	-	-	-	-	-	-	-	-
C4 Benzanthracenes/Chrysenes		0.09	0.131	0.117	0.141	0.116	-	-	-	-	-	-	-	-
C4 Dibenzothiophenes		0.38	0.687	0.479	0.938	0.421	-	-	-	-	-	-	-	-
C4 Fluoranthenes/Pyrenes		0.31	0.442	0.372	0.393	0.330	-	-	-	-	-	-	-	-
C4 Naphthalenes		0.48	0.572	0.351	0.555	0.413	-	-	-	-	-	-	-	-
C4 Phenanthrenes/Anthracenes		3.70	5.69	2.45	3.45	2.86	-	-	-	-	-	-	-	-
C1 Acenaphthenes		0.12	0.106	0.079	0.117	0.115	-	-	-	-	-	-	-	-
C1 Benz(a)Anthracenes/Chrysenes		1.34	1.36	1.09	1.27	1.07	-	-	-	-	-	-	-	-
C1 Benzofluoranthenes/Benzopyrenes		1.31	1.33	0.901	0.923	0.835	-	-	-	-	-	-	-	-
C1 Biphenyls		0.07	0.080	0.068	0.074	0.068	-	-	-	-	-	-	-	-
C1 Dibenzothiophenes		0.20	0.246	0.164	0.234	0.154	-	-	-	-	-	-	-	-
C1 Fluoranthenes/Pyrenes		1.88	1.73	1.21	1.34	1.16	-	-	-	-	-	-	-	-
C1 Fluorenes		0.17	0.147	0.113	0.141	0.116	-	-	-	-	-	-	-	-
C1 Phenanthrenes/Anthracenes		1.63	1.60	1.18	1.35	1.12	-	-	-	-	-	-	-	-
PAHs, alkylated (16 homologues)[b]		**15.97**	**19.58**	**12.67**	**16.20**	**12.81**	-	-	-	-	-	-	-	-
PAHs, total (EPA 34)[b]		**45.44**	**47.66**	**33.33**	**39.57**	**32.86**	-	-	-	-	-	-	-	-
PAHs, alkylated (all)		21.06	25.96	16.99	22.25	16.91	-	-	-	-	-	-	-	-
Polychlorinated Biphenyls	**LEL[c]**													
Aroclor 1242		<0.020	<0.030	<0.040	<0.040	<0.040	<0.10	<0.10	<0.10	<0.10	<0.10	<0.15	<0.10	<0.10
Aroclor 1248	0.03	<0.020	<0.030	<0.040	<0.040	<0.040	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Aroclor 1254	0.06	<0.020	<0.030	<0.040	<0.040	<0.040	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Aroclor 1260	0.005	<0.020	<0.030	<0.040	<0.040	<0.040	<0.10	**0.10**	<0.10	<0.10	<0.10	**0.11**	<0.10	<0.10
Total PCBs	0.07	<0.040	<0.060	<0.080	<0.080	<0.080	<0.10	**0.15**	<0.10	**0.14**	<0.10	**0.17**	<0.10	<0.10

[a] QA/QC site - mean of three box cores; [b] Recommended by USEPA (2003); [c] Lowest Effect Level - Fletcher et al. (2008)

Table 6c. Sediment petroleum hydrocarbon, oil and grease and PAH concentrations (mg/kg dw) in Lake George Channel and Upstream for 2009-2010. Values below method detection limits are indicated by "<". [Detection limits are provided in Appendix A, Table A7-A8.] Values in red exceed sediment guidelines.

Site	Guide-	170	EC38	EC47	EC48	EC39	EC49	EC50	EC51	6901	6903	EC56	EC57	52-479
Year Sampled	line	2009	2009	2010	2010	2009	2010	2010	2010	2009	2010	2010	2010	2010
Aggregate Organics														
Oil and Grease, Total		<500	1520	5620	5860	4190	7240	8850	7450	4500	560	660	560	2090
Volatile Organic Compounds														
Benzene		<0.050	<0.050	<0.050	<0.15	<0.050	<0.15	<0.20	<0.15	<0.050	<0.050	<0.050	<0.050	<0.10
Ethyl Benzene		<0.050	<0.050	<0.050	<0.15	<0.050	<0.15	<0.20	<0.15	<0.050	<0.050	<0.050	<0.050	<0.10
Toluene		<0.050	0.065	0.166	0.20	0.113	0.30	0.25	<0.15	0.054	<0.050	<0.050	<0.050	<0.10
o-Xylene		<0.050	<0.050	<0.050	<0.15	<0.050	<0.15	<0.20	<0.15	<0.050	<0.050	<0.050	<0.050	<0.10
m+p-Xylenes		<0.10	<0.10	<0.10	<0.30	<0.10	<0.30	<0.40	<0.30	<0.10	<0.10	<0.10	<0.10	<0.20
Xylenes (Total)		<0.15	<0.15	<0.15	<0.34	<0.15	<0.34	<0.45	<0.34	<0.15	<0.15	<0.15	<0.15	<0.22
Hydrocarbons	**CWS**[a]													
F1 (C6-C10)	210	<5.0	<5.0	<5.0	<15	<5.0	<15	<20	<15	<5.0	<5.0	<5.0	<5.0	<10
F1-BTEX		<5.0	<5.0	<5.0	<15	<5.0	<15	<20	<15	<5.0	<5.0	<5.0	<5.0	<10
F2 (C10-C16)	150	<10	56	33	<30	34	182	41	46	<20	<10	<10	<10	<20
F2-Naphth		<10	55	33	<30	33	182	40	45	<20	<10	<10	<10	<20
F3 (C16-C34)	1300	61	1480	1100	980	1080	9810	1550	1980	330	<50	52	<50	150
F3-PAH		61	1460	1090	970	1070	9800	1540	1970	320	<50	52	<50	150
F4 (C34-C50)	5600	<50	1070	720	740	960	6770	1120	1260	240	<50	<50	<50	<100
F4G-SG (GHH-Silica)		<500	980	1440	1670	1170	2900	2600	2800	1240	<500	540	<500	<1000
Total Hydrocarbons (C6-C50)		61	2610	1850	1720	2070	16800	2710	3290	570	<50	52	<50	150
Chrom. to baseline at nC50		YES	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES
Polycyclic Aromatic Hydrocarbons	**LEL**[b]													
Acenaphthene		<0.050	0.19	0.079	0.121	0.11	0.099	0.126	0.138	<0.10	<0.010	<0.010	<0.010	<0.010
Acenaphthylene		<0.050	0.58	0.247	0.275	0.41	0.294	0.311	0.401	0.20	<0.010	<0.010	<0.010	<0.010
Anthracene	0.22	<0.050	0.60	0.306	0.392	0.38	0.373	0.399	0.561	0.22	<0.010	<0.010	<0.010	<0.010
Benz(a)anthracene	0.32	0.059	2.44	0.856	0.83	1.46	1.08	1.30	1.97	0.77	0.021	0.013	0.011	0.018
Benzo(a)pyrene	0.37	0.050	2.36	0.695	0.913	1.53	0.970	1.15	1.44	0.777	0.021	0.013	0.011	0.016
Benzo(b&j)fluoranthene		0.066	2.72	1.12	1.05	1.64	1.38	1.58	2.30	0.92	0.038	0.029	0.023	0.036
Benzo(e)pyrene		-	-	0.593	0.760	-	0.779	0.931	1.17	-	0.020	0.017	0.015	0.021
Benzo(g,h,i)perylene	0.17	<0.050	1.32	0.595	0.719	0.94	0.745	0.906	1.08	0.55	0.020	0.019	0.015	0.044
Benzo(k)fluoranthene	0.24	0.037	1.28	0.389	0.493	0.962	0.502	0.610	0.753	0.591	0.012	<0.010	<0.010	0.013
Chrysene	0.34	0.058	2.16	1.23	1.16	1.37	1.54	1.84	2.62	0.76	0.038	0.027	0.024	0.036
Dibenz(a,h)anthracene	0.06	<0.050	0.29	0.190	0.226	0.20	0.232	0.278	0.353	0.11	<0.010	<0.010	<0.010	<0.010
Fluoranthene	0.75	0.097	3.58	1.36	1.29	2.04	1.71	2.19	2.95	1.07	0.058	0.045	0.033	0.069
Fluorene	0.19	<0.050	0.25	0.130	0.178	0.16	0.155	0.176	0.212	<0.10	<0.010	<0.010	<0.010	<0.010
Indeno(1,2,3-cd)pyrene	0.2	<0.050	1.89	0.716	0.847	1.35	0.875	1.06	1.34	0.69	0.020	0.018	0.012	0.024
Naphthalene		0.053	1.28	1.33	1.28	0.811	1.71	1.67	2.51	0.511	<0.050	<0.050	0.056	<0.050
Perylene		-	-	0.218	0.288	-	0.307	0.354	0.462	-	0.030	0.036	0.034	0.041
Phenanthrene	0.56	0.045	1.43	0.770	1.06	0.887	0.935	1.11	1.44	0.521	0.035	0.029	0.026	0.045
Pyrene	0.49	0.073	2.99	1.11	1.05	1.71	1.34	1.83	2.64	0.89	0.043	0.027	0.021	0.042
Acridine		<0.80	<1.6	0.048	0.061	<1.6	0.055	0.065	0.079	<1.6	<0.010	<0.010	<0.010	<0.010
Biphenyl		-	-	0.076	0.091	-	0.092	0.092	0.105	-	<0.010	<0.010	<0.010	<0.010
Dibenzothiophene		-	-	0.065	0.088	-	0.073	0.090	0.108	-	<0.010	<0.010	<0.010	<0.010
Quinoline		<0.050	<0.10	<0.010	<0.010	<0.10	<0.010	<0.010	0.035	<0.10	<0.010	<0.010	<0.010	<0.010
Retene		-	-	0.340	0.606	-	0.811	0.556	0.622	-	0.013	2.80	1.13	11.2
PAHs, total (18 parent compounds)	4.0	0.54	25.36	11.93	12.93	15.96	15.03	17.82	24.34	8.58	0.36	0.27	0.28	0.41

[a] For fine textured, residential/parkland land use category (CCME 2008); [b] Lowest Effect Level - Fletcher et al. (2008)

Table 6d. Sediment alkylated PAH and PCB concentrations (µg/g) in Lake George Channel and Upstream for 2009-2010. Values below method detection limits are indicated by "<". [Detection limits are provided in Appendix A, Table A7-A8.] Values in red exceed sediment guidelines.

Site	Guide-	170	EC38	EC47	EC48	EC39	EC49	EC50	EC51	6901	6903	EC56	EC57	52-479
Year Sampled	line	2009	2009	2010	2010	2009	2010	2010	2010	2009	2010	2010	2010	2010
1-Methylnaphthalene		<0.050	<0.10	0.115	0.153	<0.10	0.143	0.145	0.161	<0.10	0.010	<0.010	0.013	0.012
2-Methylnaphthalene		<0.050	0.21	0.243	0.334	0.15	0.301	0.308	0.400	<0.10	0.014	0.011	0.013	0.016
C2 sub'd B(a)A/chrysene		-	-	0.574	0.624	-	0.617	0.740	1.01	-	<0.040	<0.040	<0.040	<0.040
C2 Benzofluoranthenes/Benzopyrenes		-	-	0.252	0.313	-	0.329	0.388	0.517	-	<0.040	<0.040	<0.040	<0.040
C2 Biphenyls		-	-	0.040	0.051	-	0.061	0.061	0.062	-	<0.040	<0.040	<0.040	<0.040
C2 Dibenzothiophenes		-	-	0.178	0.204	-	0.192	0.339	0.542	-	<0.040	<0.040	<0.040	<0.040
C2 Fluoranthenes/Pyrenes		-	-	0.447	0.530	-	0.493	0.649	0.856	-	<0.040	<0.040	<0.040	<0.040
C2 Fluorenes		-	-	0.104	0.163	-	0.158	0.182	0.195	-	<0.040	<0.040	<0.040	<0.040
C2 Naphthalenes		-	-	0.832	0.873	-	1.20	1.16	0.870	-	0.071	0.058	0.061	0.077
C2 Phenanthrenes/Anthracenes		-	-	0.640	0.754	-	0.728	0.059	1.37	-	0.040	0.042	0.053	0.067
C3 Benzanthracenes/Chrysenes		-	-	0.428	0.386	-	0.298	0.437	0.570	-	<0.040	<0.040	<0.040	<0.040
C3 Dibenzothiophenes		-	-	0.187	0.273	-	0.181	0.310	0.738	-	<0.040	<0.040	<0.040	<0.040
C3 Fluoranthenes/Pyrenes		-	-	0.321	0.334	-	0.339	0.467	0.641	-	<0.040	<0.040	<0.040	<0.040
C3 Fluorenes		-	-	0.221	0.270	-	0.282	0.335	0.430	-	<0.040	<0.040	<0.040	<0.040
C3 Naphthalenes		-	-	0.358	0.487	-	0.458	0.522	0.542	-	<0.040	<0.040	0.049	0.045
C3 Phenanthrenes/Anthracenes		-	-	0.594	0.700	-	0.755	0.865	1.38	-	<0.040	0.042	0.043	0.096
C4 Benzanthracenes/Chrysenes		-	-	0.116	0.099	-	0.106	0.102	0.123	-	<0.040	<0.040	<0.040	<0.040
C4 Dibenzothiophenes		-	-	0.328	0.327	-	0.277	0.506	0.745	-	<0.040	<0.040	<0.040	<0.040
C4 Fluoranthenes/Pyrenes		-	-	0.291	0.229	-	0.279	0.360	0.468	-	<0.040	<0.040	<0.040	<0.040
C4 Naphthalenes		-	-	0.207	0.275	-	0.294	0.364	0.469	-	<0.040	<0.040	<0.040	<0.040
C4 Phenanthrenes/Anthracenes		-	-	1.14	1.45	-	1.68	1.71	2.35	-	<0.040	2.80	1.13	11.2
C1 Acenaphthenes		-	-	0.050	0.069	-	0.058	0.075	0.079	-	<0.040	<0.040	<0.040	<0.040
C1 Benz(a)Anthracenes/Chrysenes		-	-	0.737	0.872	-	0.868	1.10	1.29	-	<0.040	<0.040	<0.040	0.080
C1 Benzofluoranthenes/Benzopyrenes		-	-	0.614	0.776	-	0.795	1.04	1.39	-	<0.040	<0.040	<0.040	<0.040
C1 Biphenyls		-	-	0.041	0.055	-	0.056	0.056	0.055	-	<0.040	<0.040	<0.040	<0.040
C1 Dibenzothiophenes		-	-	0.100	0.127	-	0.114	0.156	0.226	-	<0.040	<0.040	<0.040	<0.040
C1 Fluoranthenes/Pyrenes		-	-	0.769	1.02	-	0.970	1.23	1.66	-	<0.040	<0.040	<0.040	<0.040
C1 Fluorenes		-	-	0.070	0.101	-	0.084	0.106	0.118	-	<0.040	<0.040	<0.040	<0.040
C1 Phenanthrenes/Anthracenes		-	-	0.716	0.928	-	0.814	1.06	1.35	-	<0.040	<0.040	<0.040	0.056
PAHs, alkylated (16 homologues)[a]		-	-	**7.86**	**9.49**	-	**9.76**	**10.43**	**14.29**	-	**0.14**	**2.95**	**1.36**	**11.65**
PAHs, total (EPA 34)[a]		-	-	**19.80**	**22.42**	-	**24.78**	**28.25**	**38.63**	-	**0.49**	**3.23**	**1.64**	**12.05**
PAHs, alkylated (all)		-	-	10.71	12.78	-	12.93	14.83	20.61	-	0.14	2.95	1.36	11.65
Polychlorinated Biphenyls	**LEL[b]**													
Aroclor 1242		<0.050	<0.10	<0.030	<0.030	<0.10	<0.040	<0.040	<0.030	<0.10	<0.010	<0.020	<0.010	<0.020
Aroclor 1248	0.03	<0.050	<0.10	<0.030	<0.030	<0.10	<0.040	<0.040	<0.030	<0.10	<0.010	<0.020	<0.010	<0.020
Aroclor 1254	0.06	<0.050	<0.10	<0.030	<0.030	<0.10	<0.040	<0.040	<0.030	<0.10	<0.010	<0.020	<0.010	<0.020
Aroclor 1260	0.005	<0.050	<0.10	<0.030	<0.030	<0.10	<0.040	<0.040	<0.030	<0.10	<0.010	<0.020	<0.010	<0.020
Total PCBs	0.07	<0.050	<0.10	<0.060	<0.060	<0.10	<0.080	<0.080	<0.060	<0.10	<0.020	<0.040	<0.020	<0.040

[a] Recommended by USEPA (2003); [b] Fletcher et al. (2008)

Table 7. Probabilities of 2009-2010 sites belonging to Great Lakes faunal groups.

Site	Year	Probability of Faunal Group Membership				
		Group 1	Group 2	Group 3	Group 4	Group 5
EC30	2009	**0.938**	0.004	0.000	0.000	0.058
EC31	2009	**0.913**	0.006	0.001	0.000	0.080
EC32	2009	**0.885**	0.008	0.001	0.000	0.107
EC33	2009	**0.941**	0.005	0.000	0.000	0.054
EC34	2009	**0.915**	0.006	0.001	0.000	0.078
EC35	2009	**0.927**	0.006	0.001	0.000	0.067
EC36	2009	**0.854**	0.012	0.003	0.000	0.130
EC37	2009	**0.930**	0.006	0.001	0.000	0.063
EC52	2010	**0.812**	0.021	0.015	0.000	0.152
EC53	2010	**0.910**	0.007	0.001	0.000	0.082
EC54	2010	**0.928**	0.007	0.001	0.000	0.064
170	2009	**0.717**	0.036	0.095	0.000	0.152
EC38	2009	**0.872**	0.014	0.007	0.000	0.108
EC39	2009	**0.886**	0.010	0.003	0.000	0.100
6901	2009	**0.908**	0.010	0.004	0.000	0.078
EC47	2010	**0.879**	0.012	0.005	0.000	0.103
EC48	2010	**0.882**	0.010	0.002	0.000	0.106
EC49	2010	**0.907**	0.009	0.002	0.000	0.082
EC50	2010	**0.904**	0.009	0.002	0.000	0.085
EC51	2010	**0.900**	0.008	0.002	0.000	0.090
EC56	2010	**0.773**	0.032	0.043	0.000	0.153
EC57	2010	**0.740**	0.035	0.057	0.000	0.167
52-479	2010	**0.785**	0.030	0.040	0.000	0.145
6903	2010	**0.713**	0.040	0.081	0.000	0.167

Table 8a. Mean density (no. per 33 cm^{-2}) and of predominant macroinvertebrate families sampled in 2009-2010 and taxon diversity (based on 38-family bioassessment model and total number of all macroinvertebrate taxa) in East Bellevue Marine Park**.** Mean density and percent occurrence of these families for Great Lakes Reference Group 1 is shown for comparison.

Year	Gp. 1	Gp. 1	2010	2010	2010	2009	2009	2009	2009	2009	2009	2009	2009
Site	Mean[a]	%Occur[a]	**EC52[b]**	**EC53**	**EC54**	**EC30**	**EC31**	**EC32**	**EC33[b]**	**EC34**	**EC35**	**EC36**	**EC37**
No. taxa (GL-38 family model)	8 2-14 (2 SD)	-	16	11	12	6	6	5	7	5	9	11	5
No. taxa (all)	-	-	19	13	17	7	6	6	8	7	10	12	6
Chironomidae	13.4	39.9	28.0	34.4	58.6	18.4	3.0	6.6	14.5	13.8	26.2	39.2	25.6
Tubificidae	5.6	16.7	21.4	7.8	8.0	45.2	92.8	81.8	23.3	86.2	75.8	47.0	33.0
Sphaeriidae	4.9	14.7	0.2	0.0	0.0	0.2	0.6	0.0	0.1	1.2	0.6	0.4	0.0
Asellidae	1.8	5.5	0.3	3.4	8.6	0.0	0.0	0.0	0.0	0.0	4.4	1.6	1.0
Naididae	1.4	4.3	2.0	1.0	3.2	7.0	30.8	8.8	0.7	8.0	6.4	5.8	0.6
Sabellidae	1.2	3.6	5.7	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.2	5.2	0.0
Gammaridae	0.6	1.6	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyalellidae	0.03	0.1	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Ephemeridae	0.4	1.1	8.9	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Leptoceridae	0.2	0.6	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BEAST Cat[c]	-	-	1	1	1	2	4	2	1	2	2	2	1
SDMF Rank[d]	-	-	□	□	□	▣	■	▣	□	▣	▣	▣	□

[a] Environment Canada, unpublished data
[b] QA/QC site, counts are average of 3 box core drops
[c] Overall result based on 3-dimensional HMDS of a subset of 3 or 4 sites with Great Lakes reference Group 1 sites (n=108)
[d] SDMF = sediment decision-making framework (EC/MOE 2007)

Table 8b. Mean density (no. per 33 cm^{-2}) and of predominant macroinvertebrate families sampled in 2009-2010 and taxon diversity (based on 38-family bioassessment model and total number of all macroinvertebrate taxa) in Lake George Channel and at upstream locations. Mean abundance and percent occurrence of these families for Great Lakes Reference Group 1 is shown for comparison. Sites are listed from upstream to downstream or west to east.

Year	Gp. 1	Gp.1	2009	2009	2009	2010	2010	2010	2010	2010	2009	2010	2010	2010	2010
Site	Mean[a]	%Occur[a]	**170**	**EC38**	**EC39**	**EC47**	**EC48**	**EC49**	**EC50**	**EC51**	**6901**	**EC56**	**EC57**	**52-479**	**6903**
No. taxa (GL-38 family model)	8 2-14 (2 SD)	-	15	6	5	5	5	9	8	13	8	8	9	9	13
No. taxa (all)	-	-	19	7	5	6	5	10	12	14	9	9	10	10	18
Chironomidae	13.4	39.9	203.6	15.4	4.6	24.6	22.0	15.4	31.4	34.2	29.8	28.8	28.0	27.4	110.2
Tubificidae	5.6	16.7	18.0	112.8	101.2	5.4	11.0	42.6	7.0	2.6	37.6	6.0	2.2	2.0	17.2
Sphaeriidae	4.9	14.7	0.0	0.0	0.0	0.0	0.0	0.4	0.0	1.6	0.6	1.2	1.6	0.8	3.0
Asellidae	1.8	5.5	0.8	0.0	0.0	0.0	0.0	16.0	3.4	1.2	3.8	1.0	2.2	0.4	0.4
Naididae	1.4	4.3	0.6	9.0	10.6	0.4	0.8	1.2	32.0	1.2	2.4	3.0	3.6	2.0	20.4
Sabellidae	1.2	3.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
Gammaridae	0.6	1.6	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Hyalellidae	0.03	0.1	0.0	0.0	0.0	0.0	0.0	3.2	0.8	0.2	0.0	0.0	0.0	0.0	0.0
Ephemeridae	0.4	1.1	6.6	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	2.4	1.8	2.2	7.8
Leptoceridae	0.2	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BEAST Cat[b]	-	-	3	2	3	1	1	2	1	1	1	1	1	1	2
SDMF Rank[c]	-	-	■	▣	■	□	□	▣	□	□	□	□	□	□	▣

[a] Environment Canada, unpublished data
[b] Overall result based on 3-dimensional HMDS of a subset of 4 or 5 sites with Great Lakes reference Group 1 sites (n=108)
[c] SDMF = sediment decision-making framework (EC/MOE 2007)

Table 9. Mean percent survival, growth (mg dry weight per individual) and reproduction for 2009-2010. Toxicity, based on numerical guidelines (Reynoldson and Day 1998), is indicated in red and potential toxicity in blue.

Site	Year	*C. riparius*		*H. azteca*		*Hexagenia* spp.		*T. tubifex*				BEAST Cat[b]	SDMF Rank[c]
		% survival	growth	% survival	growth	% survival	growth	% survival	No. cocoons/ adult	% hatch	No. young/ adult		
GL Ref Mean[a]		87.1	0.35	85.6	0.50	96.2	3.03	97.9	9.9	57.0	29.0		
EC52	2010	83.3	0.251	80.0	0.498	97.5	0.96	100	**4.6**	**29.0**	**7.2**	2	▣
EC53	2010	90.7	0.378	92.0	0.373	98	**0.61**	100	10.8[d]	**28.5**	**8.2**	2	▣
EC54	2010	73.3	**0.109**	94.7	0.349	94	1.90	100	9.8	**36.5**	13.7	2	▣
EC30	2009	73.3	0.328	78.7	**0.181**	**84**	**0.10**	100	9.7[d]	**32.7**	**7.9**	3	▣
EC31	2009	90.7	0.304	**44.0**	**0.177**	98	1.69	100	9.9[d]	**31.8**	**6.9**	4	▣
EC32	2009	**66.7**	0.334	90.7	0.477	100	3.56	100	10.0[d]	**15.0**	**1.9**	4	▣
EC33	2009	82.7	0.348	98.7	0.470	100	5.58	100	9.8[d]	**12.9**	**1.7**	4	▣
EC34	2009	**40.0**	0.210	86.7	0.378	98	**0.29**	100	9.4	46.6	12.4	4	▣
EC35	2009	**24.0**	**0.191**	85.3	0.419	95	**0.36**	100	9.2	57.4	14.1	4	▣
EC36	2009	88.0	0.305	84.0	0.582	100	**0.84**	100	9.8[d]	41.9	11.0	1	□
EC37	2009	88.0	0.311	100.0	0.418	100	1.33	100	10.2	**36.2**	10.5	2	□
EC47	2010	85.3	**0.187**	**54.7**	**0.211**	92	1.98	100	10.0[d]	**28.8**	**6.1**	4	▣
EC48	2010	90.7	0.241	**22.0**	**0.171**	98	2.50	100	10.0[d]	**12.3**	**2.4**	4	■
EC49	2010	90.7	0.375	92.0	0.478	100	6.69	100	11.6	57.7	30.5	1	□
EC50	2010	89.3	0.249	**61.7**	0.340	100	1.37	100	10.6	39.5	11.5	2	□
EC51	2010	90.7	0.379	78.7	0.446	94	**0.55**	100	10.6	48.5	20.7	1	□
EC38	2009	98.7	0.312	96.0	0.555	100	2.46	100	10.2	52.8	18.5	1	□
EC39	2009	92.0	0.302	98.7	0.465	100	3.65	100	9.8[d]	**5.4**	**0.9**	4	▣
6901	2009	85.3	0.379	92.0	0.431	100	5.77	100	11.2	57.9	30.1	1	□
EC56	2010	70.7	0.272	72.0	0.329	100	2.91	100	10.0	57.7	22.9	2	□
EC57	2010	91.7	0.298	73.3	0.428	94	3.11	100	11.2	58.3	28.3	1	□
52-479	2010	89.3	0.331	**65.3**	0.375	98	2.98	100	10.9	57.7	28.6	1	□
6903	2010	78.7	0.318	93.3	0.584	96	3.50	100	10.9	60.4	27.0	1	□
Non-toxic[e]	-	≥67.7	0.49-0.21	≥67.0	0.75- 0.23	≥85.5	5.0 – 0.9	≥88.9	12.4 – 7.2	78.1-38.1	46.3 – 9.9	-	-
Pot. toxic	**-**	**67.6-58.8**	**0.20-0.14**	**66.9-57.1**	**0.22-0.10**	**85.4-80.3**	**0.89 – 0**	**88.8-84.2**	**7.1 – 5.9**	**38.0-28.1**	**9.8 – 0.8**	**-**	**-**
Toxic	**-**	**< 58.8**	**< 0.14**	**< 57.1**	**< 0.10**	**< 80.3**	**negative**	**< 84.2**	**< 5.9**	**< 28.1**	**< 0.8**	**-**	**-**

[a] Environment Canada, unpublished data; [b] Overall results based on 3-dimensional HMDS of a subset of 3 to 5 sites with Great Lakes reference sites (n=136)
[c] SDMF = sediment decision-making framework (EC/MOE 2007); [d] most cocoons looked dead; [e] The upper limit for non-toxic category is set using 2 × standard deviation of the mean and indicates excessive growth or reproduction (Reynoldson and Day 1998)

Table 10. Toxic units (TUs) associated with 2009-2010 St. Marys River sediment PAH concentrations.

Area	Site	Year	No. PAH Compounds	∑ TUs
East Bellevue Marine Park	EC52[a]	2010	34	**1.57-2.62**
	EC53	2010	34	**1.13**
	EC54	2010	34	0.78
	EC31	2010	34	0.72
	EC64	2010	34	0.79
	EC30	2009	18	0.39
	EC31	2009	18	0.38
	EC32	2009	18	0.40
	EC33[a]	2009	18	0.42-0.54
	EC34	2009	18	0.41
	EC35	2009	18	0.51
	EC36	2009	18	0.75
	EC37	2009	18	0.78
Lake George Channel	EC47	2010	34	0.66
	EC48	2010	34	0.61
	EC49	2010	34	0.66
	EC50	2010	34	0.75
	EC51	2010	34	0.97
	EC38	2009	18	0.88
	EC39	2009	18	0.45
	170	2009	18	0.25
	6901	2009	18	0.26

[a] QA/QC site

Table 11a. Decision matrix for weight-of-evidence categorization of Bellevue Marine Park sites for 2002 to 2006, based on three lines of evidence.

Site	Year	Sediment Chemistry	Toxicity	Benthos Alteration	>LEL or CWS	tPAHs	tPHCs	tOil/ Grease	Assessment
6986	2006[b]	▣	□	▣[a]	8 metals, PAHs	4.7	2140	927	No further actions needed
6986	2002[c]	■	▣	□	7 metals, F3, F4	2.8	8450	ND	Determine reason(s) for sediment toxicity
6991	2006[b]	■	□	□	9 metals, F3	3.1	2858	751	No further actions needed
6991	2002[c]	■	■	□	9 metals, PAHs, F3, F4	6.7	6220	ND	Determine reason(s) for sediment toxicity
6992	2006[b]	▣	□	□	8 metals, PAHs	6.3	1666	365	No further actions needed
6992	2002[c]	■	□	□	9 metals, PAHs, F3, F4	5.2	6560	ND	No further actions needed
6981	2002[c]	▣	□	▣[a]	8 metals, PAHs	7.0	367	ND	No further actions needed
6983	2002[c]	■	□	□	8 metals, F3, F4	4.0	3740	ND	No further actions needed
6984	2002[c]	▣	□	▣[a]	5 metals	2.3	1871	ND	No further actions needed
EC70	2006[b]	■	□	▣[a]	3 metals, PAHs, F3	28.7	700	387	No further actions needed
M219	2006[b]	▣	□	▣[a]	5 metals, PAHs	14.8	1061	687	No further actions needed
M221	2006[b]	▣	□	▣[a]	3 metals	3.5	214	141	No further actions needed
M223	2006[b]	▣	□	▣[a]	3 metals	2.4	320	183	No further actions needed
M224	2006[b]	▣	□	□	8 metals	2.5	1220	315	No further actions needed
M225	2006[b]	▣	□	□	6 metals, PAHs	30.9	802	624	No further actions needed
M226	2006[b]	▣	□	▣[a]	3 metals	4.0	189	324	No further actions needed

[a] Benthos not considered degraded based on abundance and/or taxon diversity
[b] Milani and Grapentine (2009)
[C] Milani and Grapentine (2006)
ND = not determined

Table 11b. Decision matrix for weight-of-evidence categorization of East Bellevue Marine Park sites for 2006 to 2010, based on three lines of evidence. See text for description of how results for each line of evidence were determined.

Site	Year	Sediment Chemistry	Toxicity	Benthos Alteration	>LEL or CWS	tPAHs	tPHCs	tOil/ Grease	Assessment
EC52	2010	◘	◘	□	PAHs, 1 metal	29.5	590	1616[b]	Determine reason(s) for sediment toxicity
EC53	2010	◘	◘	□	PAHs, F3, 7 metals	28.1	3280	5857[b]	Determine reason(s) for sediment toxicity
EC54	2010	◘	◘	□	PAHs, F3, 7 metals	20.7	2990	6493[b]	Determine reason(s) for sediment toxicity
EC30	2009	◘	◘	◘	PAHs, 9 metals, F3 PHC	23.6	2440	8690	Management actions required
EC31	2009	◘	◘	■	PAHs, 9 metals	19.2	2000	8270	Management actions required
EC32	2009	◘	◘	◘	PAHs, 9 metals	18.8	785	8250	Management actions required
EC33	2009	◘	◘	□	PAHs, 10 metals, F3 PHC	26.8	2413	12100	Determine reason(s) for sediment toxicity
EC34	2009	◘	◘	◘	PAHs, 9 metals	20.0	1760	14000	Management actions required
EC35	2009	◘	◘	◘	PAHs, 9 metals, F3 PHC	25.4	3740	6650	Management actions required
EC36	2009	◘	□	◘	PAHs, 8 metals	25.5	1370	4470	Determine reason(s) for benthos alteration
EC37	2009	◘	□	□	PAHs, 10 metals, F3 PHC	38.9	4290	2340	No further actions needed
CS6	2008[c]	◘	◘	□	PAHs, 9 metals	16.1	740	500	Determine reason(s) for sediment toxicity
CS7	2008[c]	◘	□	◘	PAHs, 9 metals	13.8	1230	300	Determine reason(s) for benthos alteration
CS8	2008[c]	◘	◘	□	PAHs, 9 metals	14.6	1470	400	Determine reason(s) for sediment toxicity
CS9	2008[c]	◘	□	◘[a]	PAHs, 9 metals	16.4	877	500	No further actions needed
CS10	2008[c]	◘	◘	◘	PAHs, 9 metals	15.1	1650	500	Management actions required
CS11	2008[c]	◘	□	◘	PAHs, 9 metals	10.9	700	300	Determine reason(s) for benthos alteration
CS12	2008[c]	◘	□	◘[a]	PAHs, 9 metals	52.1	1810	600	No further actions needed
EC15	2008[c]	◘	□	◘[a]	PAHs, 9 metals, F4 PHC	13.3	7570	300	No further actions needed
EC16	2008[c]	◘	◘	□	PAHs, 9 metals	12.1	1070	500	Determine reason(s) for sediment toxicity
EC26	2008[c]	◘	■	□	PAHs, 9 metals	18.0	1420	1300	Determine reason(s) for sediment toxicity
EC64	2008[c]	◘	■	◘[a]	PAHs, 9 metals	13.9	1120	500	Determine reason(s) for sediment toxicity
EC64	2006[d]	◘	■	■	F3, 9 metals	3.4	3358	648	Management actions required
EC63	2006[d]	◘	◘	◘	9 metals	4.2	2300	361	Determine reason(s) for sediment toxicity and benthos alteration

[a] Benthos not considered degraded based on abundance and/or taxon diversity
[b] Mean of three lab values
[c] Milani and Grapentine (2010)
[d] Milani and Grapentine (2009)

Table 11c. Decision matrix for weight-of-evidence categorization of Lake George Channel sites for 2002 to 2010, based on three lines of evidence. Sites are listed from upstream to downstream or west to east. See text for description of how results for each line of evidence were determined.

Site	Year	Sediment Chemistry	Toxicity	Benthos Alteration	>LEL or CWS	tPAHs	tPHCs	tOil/ Grease	Assessment
EC47	2010	◘	◘	□	PAHs, 6 metals	11.9	1850	3343[b]	Determine reason(s) for sediment toxicity
EC48	2010	◘	■	□	PAHs, 5 metals	12.9	1720	3397[b]	Determine reason(s) for sediment toxicity
EC49	2010	◘	□	◘	PAHs, F3, F4, 5 metals	15.0	16800	4703[b]	Determine reason(s) for benthos alteration
EC50	2010	◘	□	□	PAHs, F3, 7 metals	17.8	2710	4900[b]	No further actions needed
EC51	2010	◘	□	□	PAHs, F3, 8 metals	24.3	3290	4537[b]	No further actions needed
EC38	2009	◘	□	◘	PAHs, F3, 5 metals	25.6	2610	1520	Determine reason(s) for benthos alteration
EC39	2009	◘	◘	■	PAHs, 6 metals	16.1	2070	4190	Management action required
EC22	2008[c]	◘	□	□	PAHs, 2 metals	4.5	340	300	No further actions needed
EC25	2008[c]	◘	□	□	PAHs, 1 metal	8.2	392	400	No further actions needed
EC29	2008[c]	◘	◘	◘[a]	PAHs, 8 metals	10.1	1150	500	Determine reason(s) for sediment toxicity
DBCR1	2008[c]	◘	◘	◘	PAHs, 7 metals	9.6	790	800	Management actions required
EC46	2006[d]	◘	■	□	F3, 7 metals	4.0	2374	2360	Determine reason(s) for sediment toxicity
6901	2009	◘	□	□	PAHs, 3 metals	8.6	570	4500	No further actions needed
6901	2006[d]	◘	□	□	F3, 7 metals	1.9	3031	724	No further actions needed
6901	2002[e]	◘	□	◘	F3, F4, 8 metals	1.9	6370	ND	Determine reason(s) for benthos alteration
170	2009	□	ND	■	-	0.5	61	ND	Determine reason(s) for benthos alteration
170	2006[d]	□	◘	◘	-	0.9	32	108	Determine reason(s) for sediment toxicity and benthos alteration
170	2002[e]	◘	◘	◘	3 metals	0.7	32	ND	Determine reason(s) for sediment toxicity and benthos alteration
172	2002[e]	◘	□	□	F3, 9 metals	1.7	2923	ND	No further actions needed
175	2002[e]	◘	◘	□	6 metals	2.8	1630	ND	Determine reason(s) for sediment toxicity
176 (US)	2002[e]	◘	◘	□	7 metals	1.6	1325	ND	Determine reason(s) for sediment toxicity
6900 (US)	2002[e]	◘	□	◘	6 metals	2.8	1712	ND	Determine reason(s) for benthos alteration

[a] Benthos not considered degraded based on abundance and/or taxon diversity
[b] Mean of three lab values
[c] Milani and Grapentine (2010)
[d] Milani and Grapentine (2009)
[e] Milani and Grapentine (2006)
ND = not determined

Table 12. Summary comparison of decision-making framework assessment outcomes for St. Marys River depositional areas, 2002 to 2010.

Area	Bellevue Marine Park	East Bellevue Marine Park	Lake George Channel
Years sampled	2002, 2006	2006, 2008-2010	2002, 2006, 2008-2010
Total no. sites*	13	23	18
Assessment Outcomes (No. of sites)			
a) management actions required	0	7	2
b) determine reason(s) for toxicity	2	8	6
c) determine reasons for benthos alteration	0	3	3
d) both b) and c)	0	1	1
e) no further actions needed	11	4	6

* Some sites were resampled once or twice

FIGURES

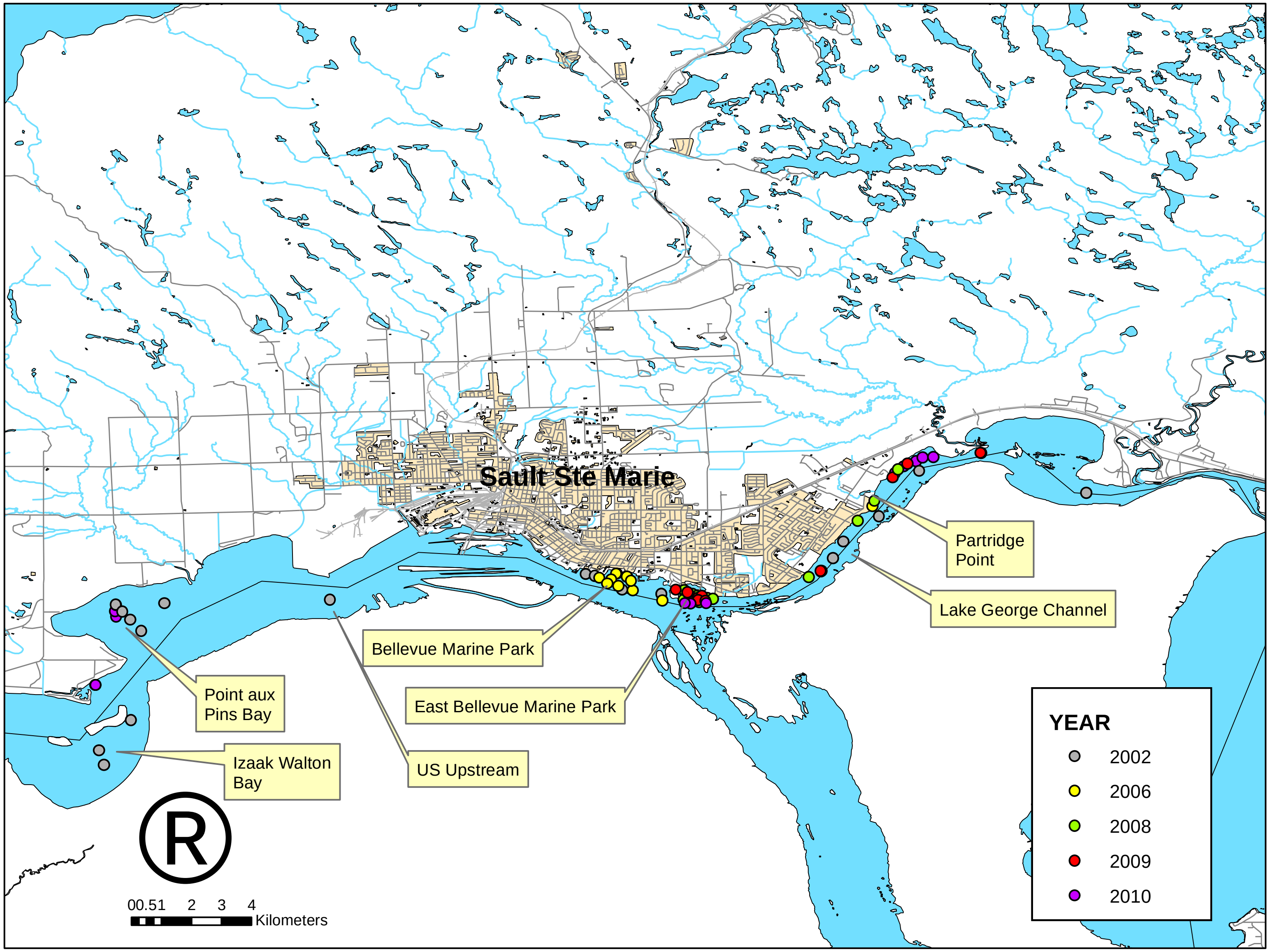


Figure 1a. St. Marys River sampling locations for 2002 to 2010.

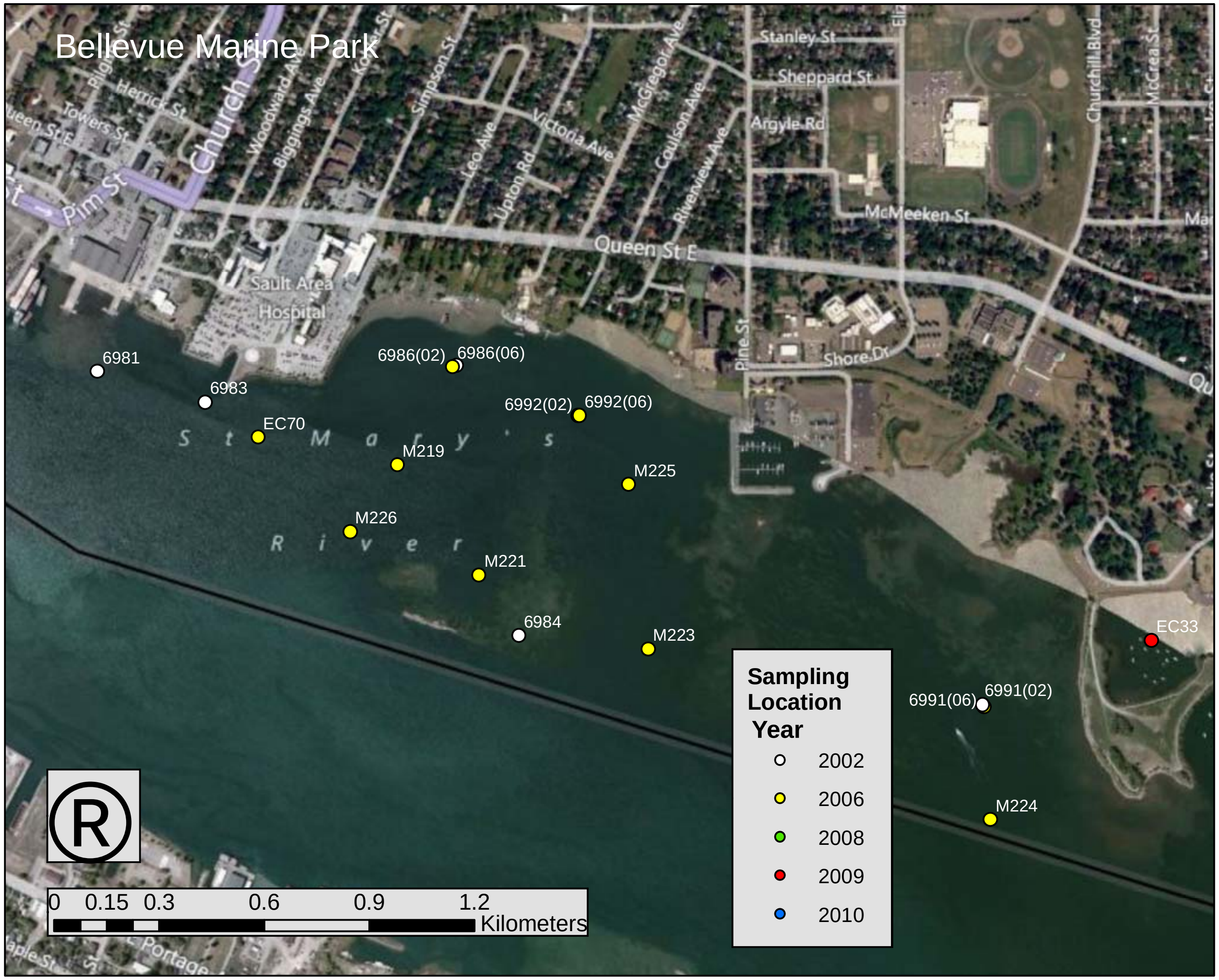


Figure 1b. Bellevue Marine Park sampling locations for 2002 to 2006.

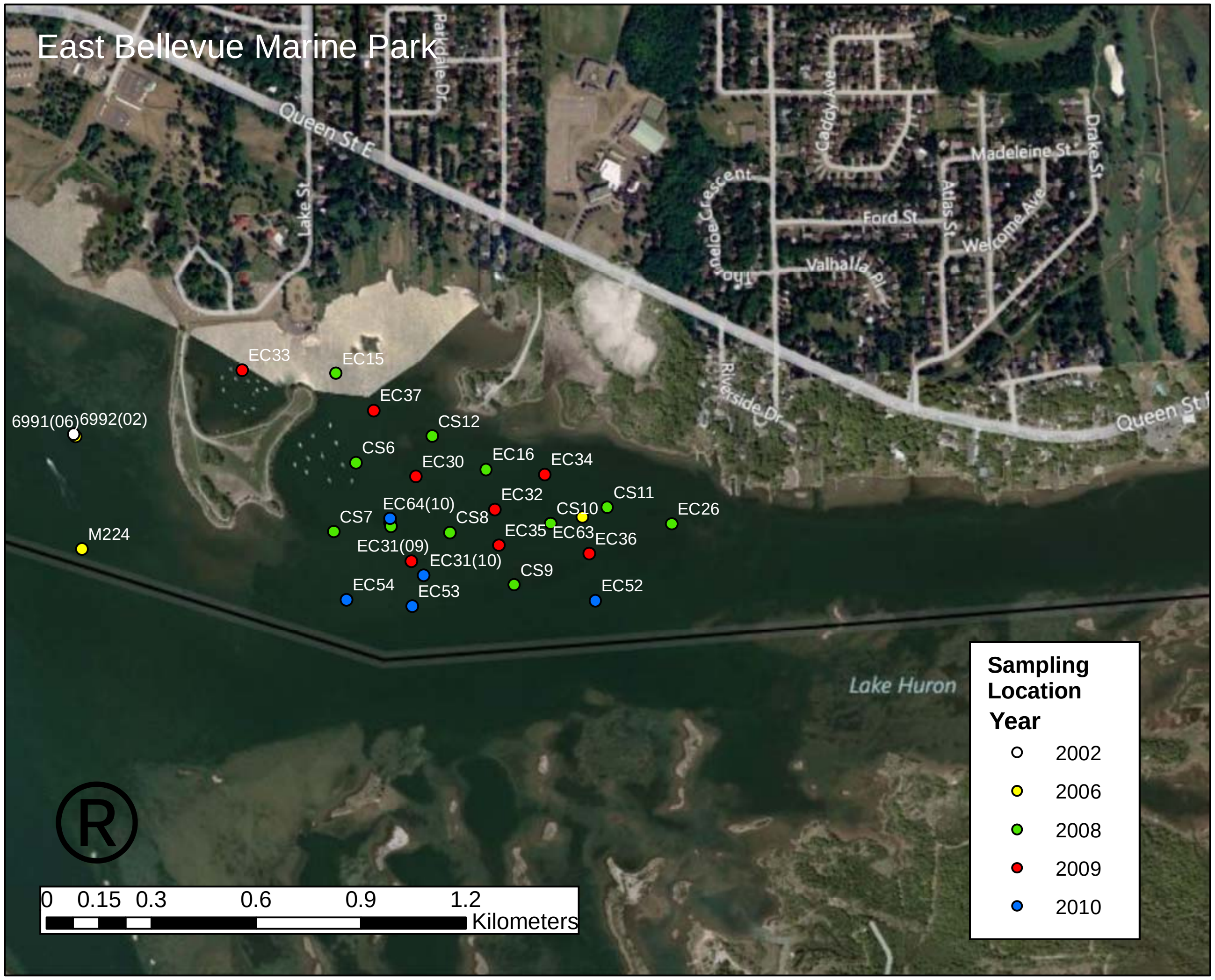


Figure 1c. East Bellevue Marine Park sampling locations for 2006 to 2010.

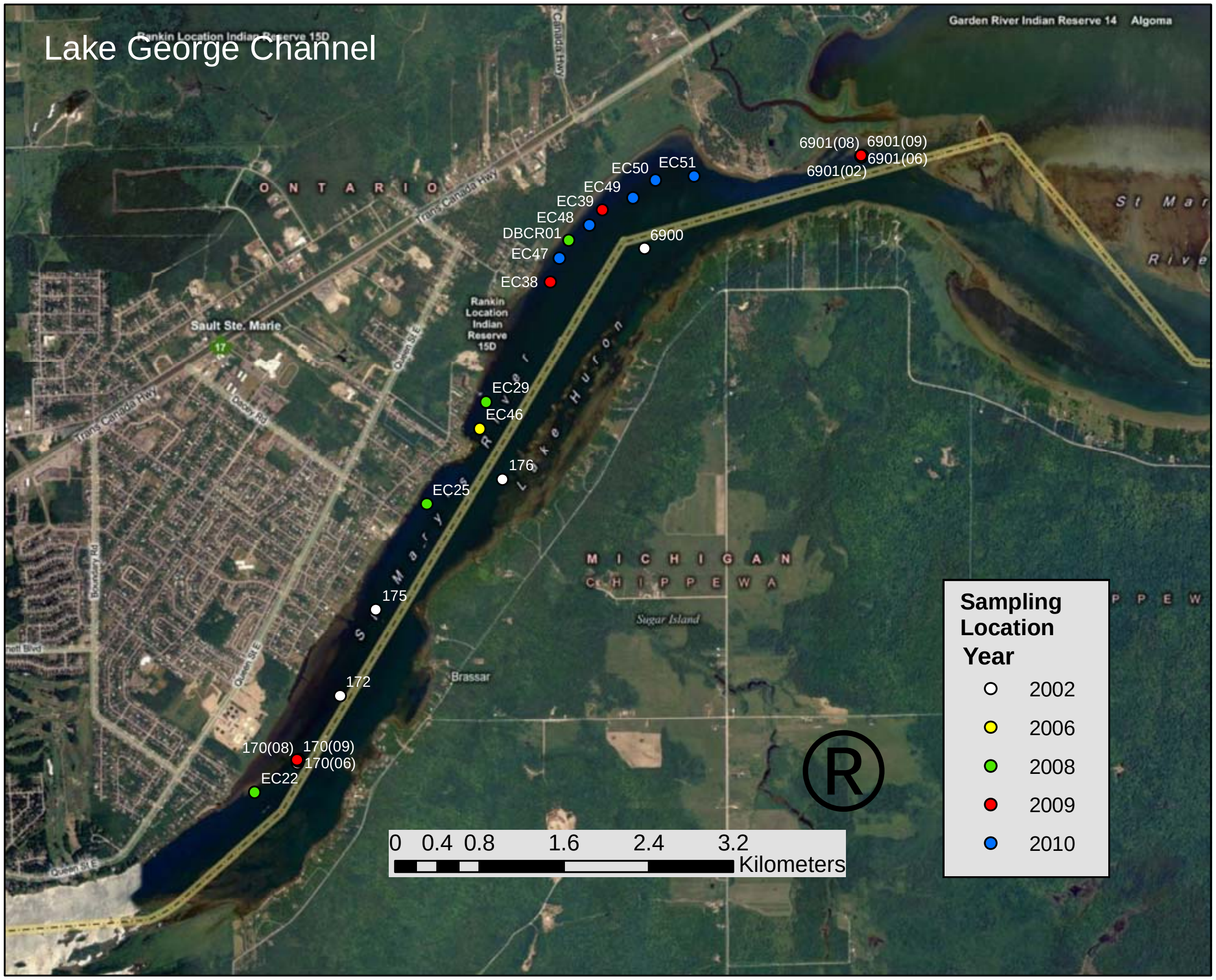


Figure 1d. Lake George Channel sampling locations for 2002 to 2010.

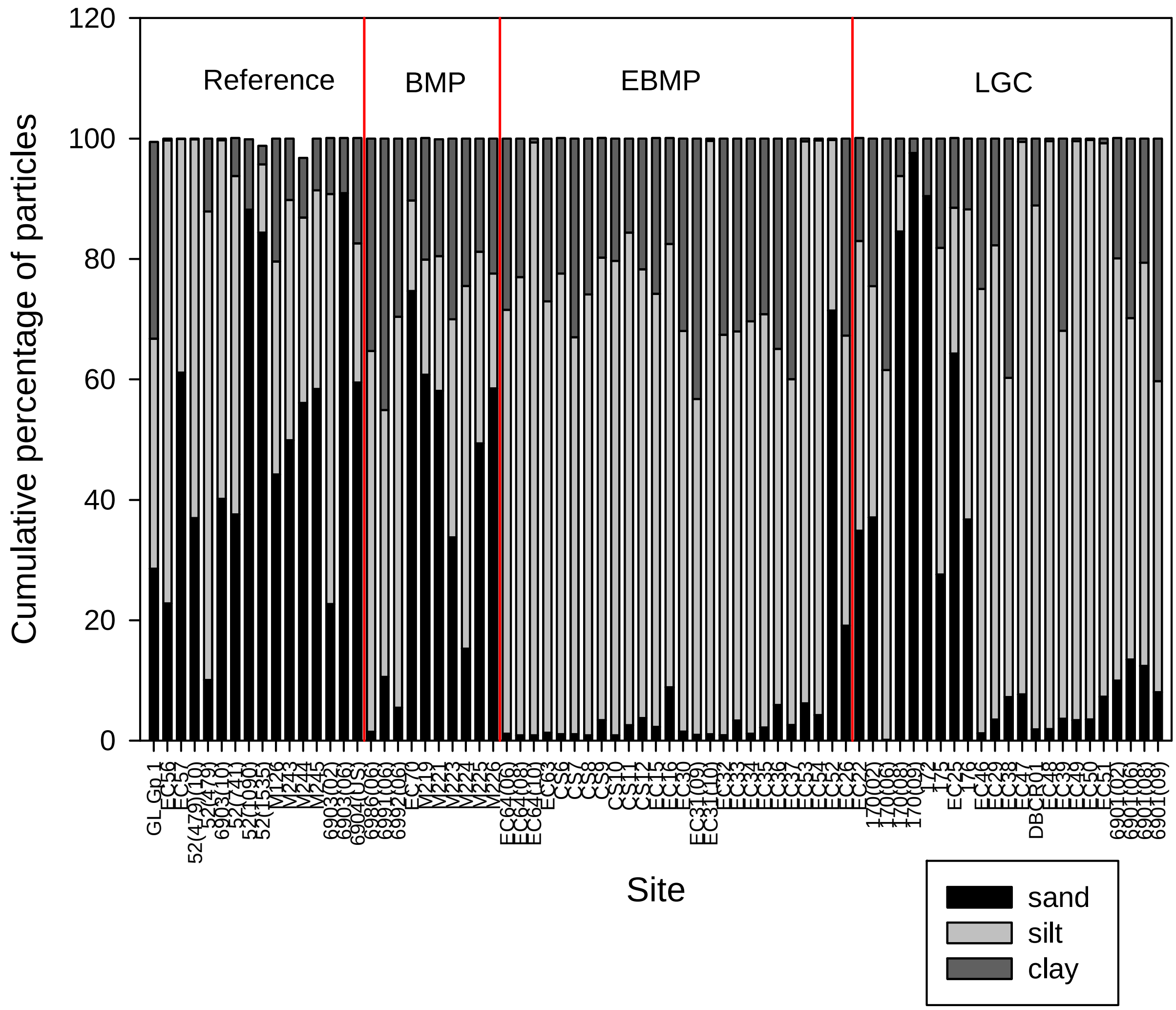


Figure 2. Particle size distributions in sediment from reference locations (Great Lakes and upstream), Bellevue Marine Park (BMP), East Bellevue Marine Park (EBMP) and Lake George Channel (LGC) for 2002 to 2010.

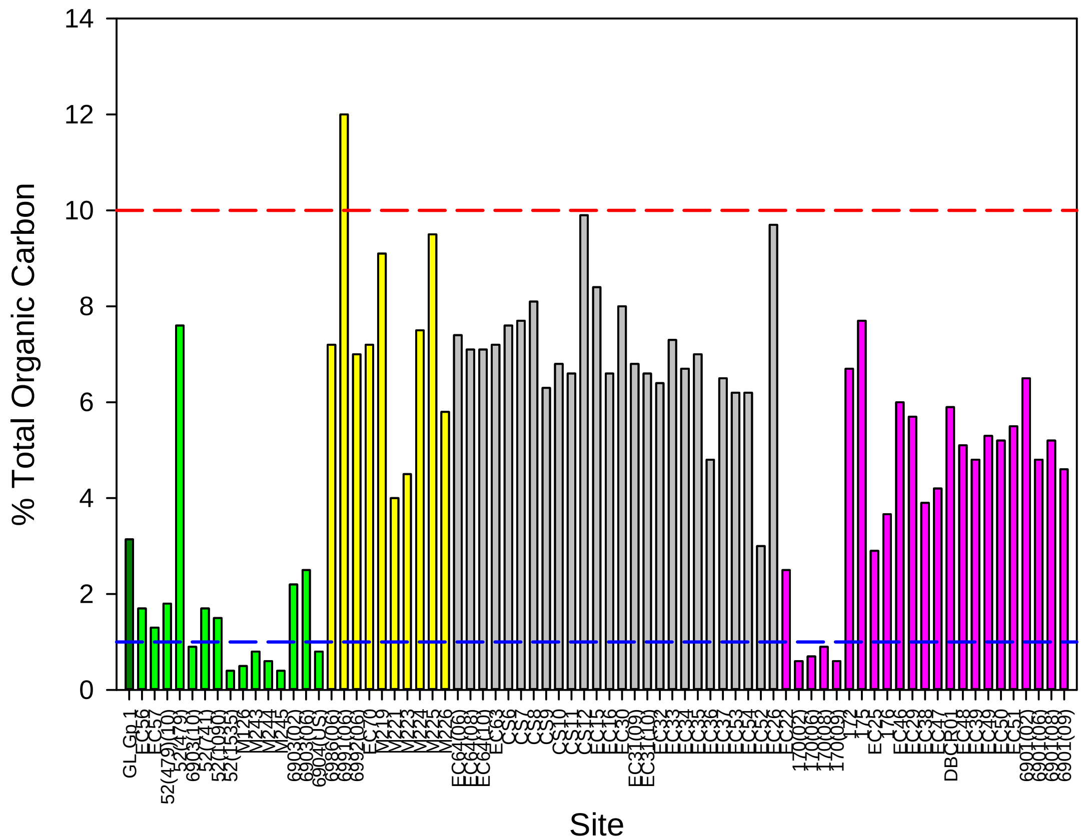


Figure 3. Total organic carbon (%) in sediment from reference locations (Great Lakes and upstream - green bars), Bellevue Marine Park (yellow bars), East Bellevue Marine Park (grey bars) and Lake George Channel (pink bars) for 2002 to 2010. The Lowest and Severe Effect Levels are indicated by the blue (1%) and red (10%) dashed lines.

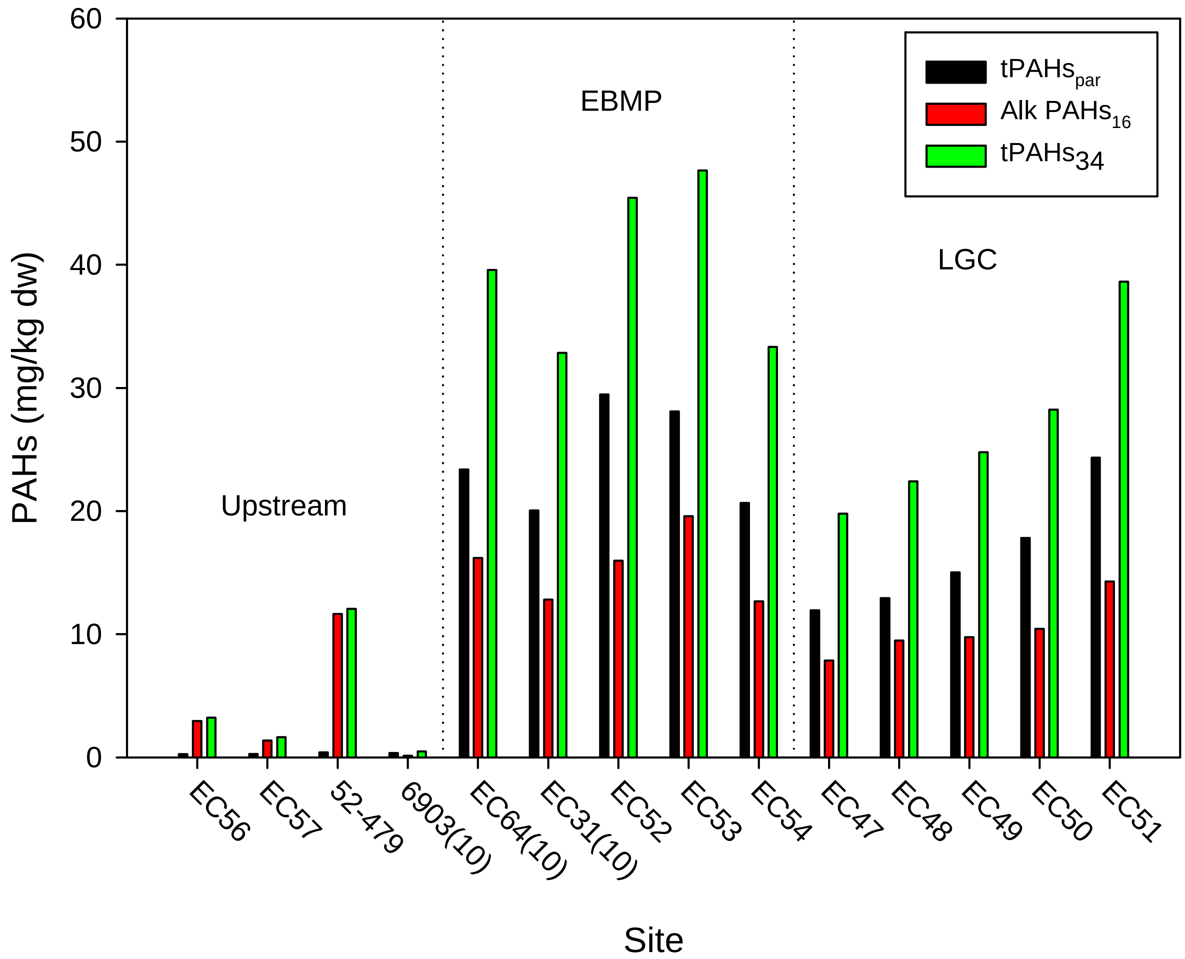


Figure 4. Sediment PAH concentrations (mg/kg dw) based on priority parent compounds ($tPAH_{par}$), 16 alkylated homologues (Alk PAH_{16}) and parent + alkylated compounds ($tPAH_{34}$) for 2010 upstream, East Bellevue Marine Park (EBMP) and Lake George Channel (LGC) sites.

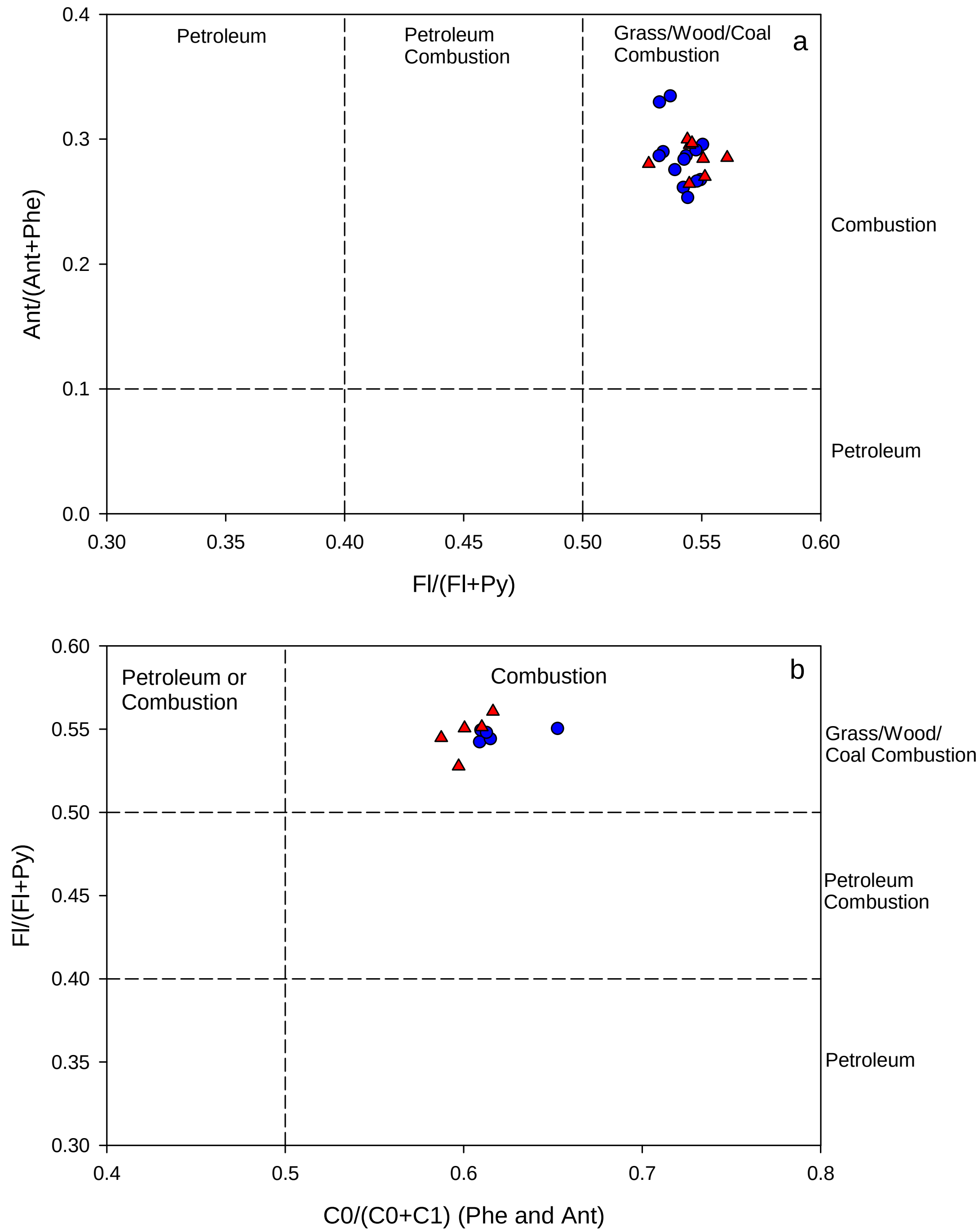


Figure 5. Cross plots for PAH ratios of (a) Anthracene/ (Anthracene+Phenanthrene) against Fluoranthene/ (Fluoranthene + Pyrene), (b) C0/ (C0+C1) of Phe + Ant ratio against Fl/ (Fl+Py). Subplot (a) is for 2009-2010 sites and Subplot (b) for 2010 sites. East Bellevue Marine Park sites = blue circle, Lake George Channel sites = red triangle.

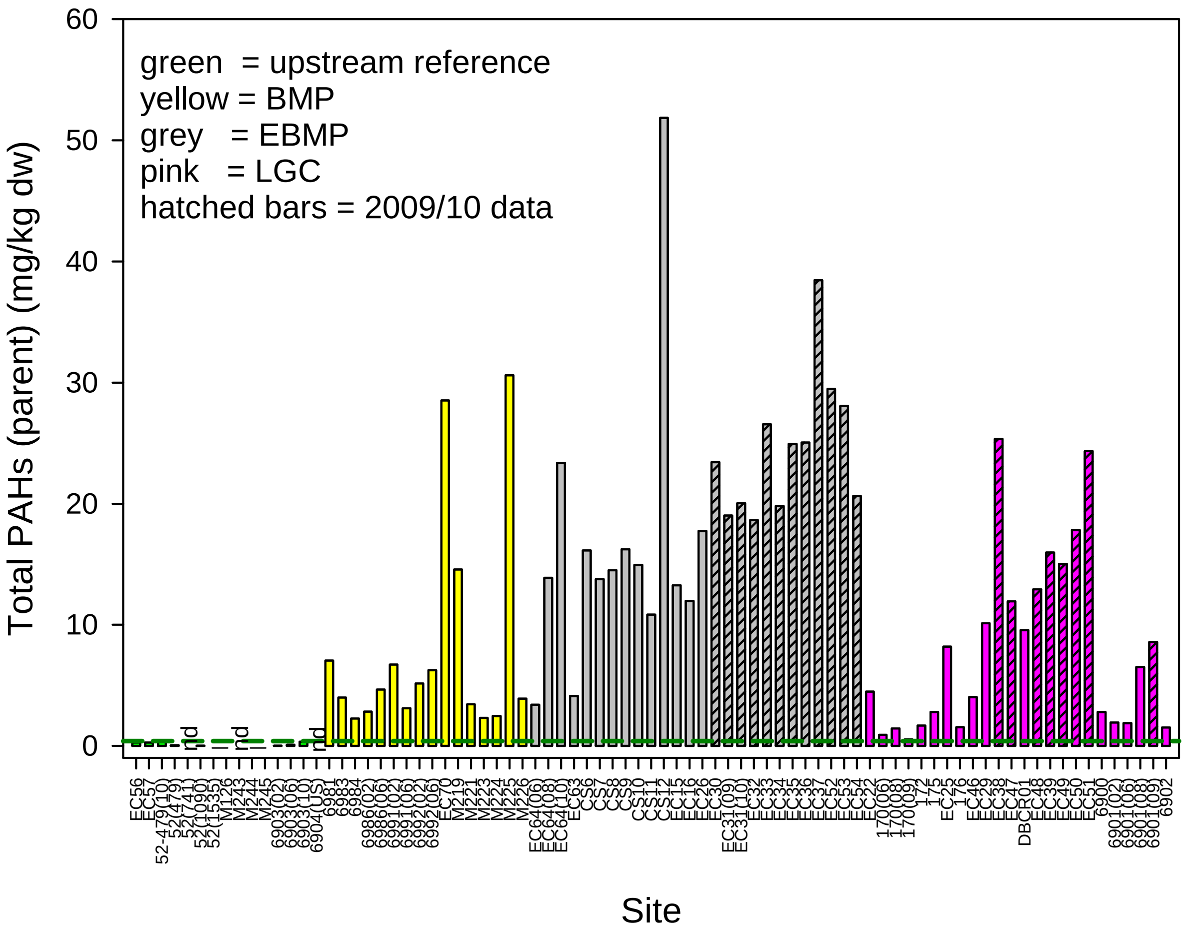


Figure 6. Total PAHs (parent compounds) (mg/kg dw) in St. Marys River sediment for 2002 to 2010. Bars are colour-coded for each area of the river. The green dashed line represents the upper 99th percentile concentration for upstream reference sites.

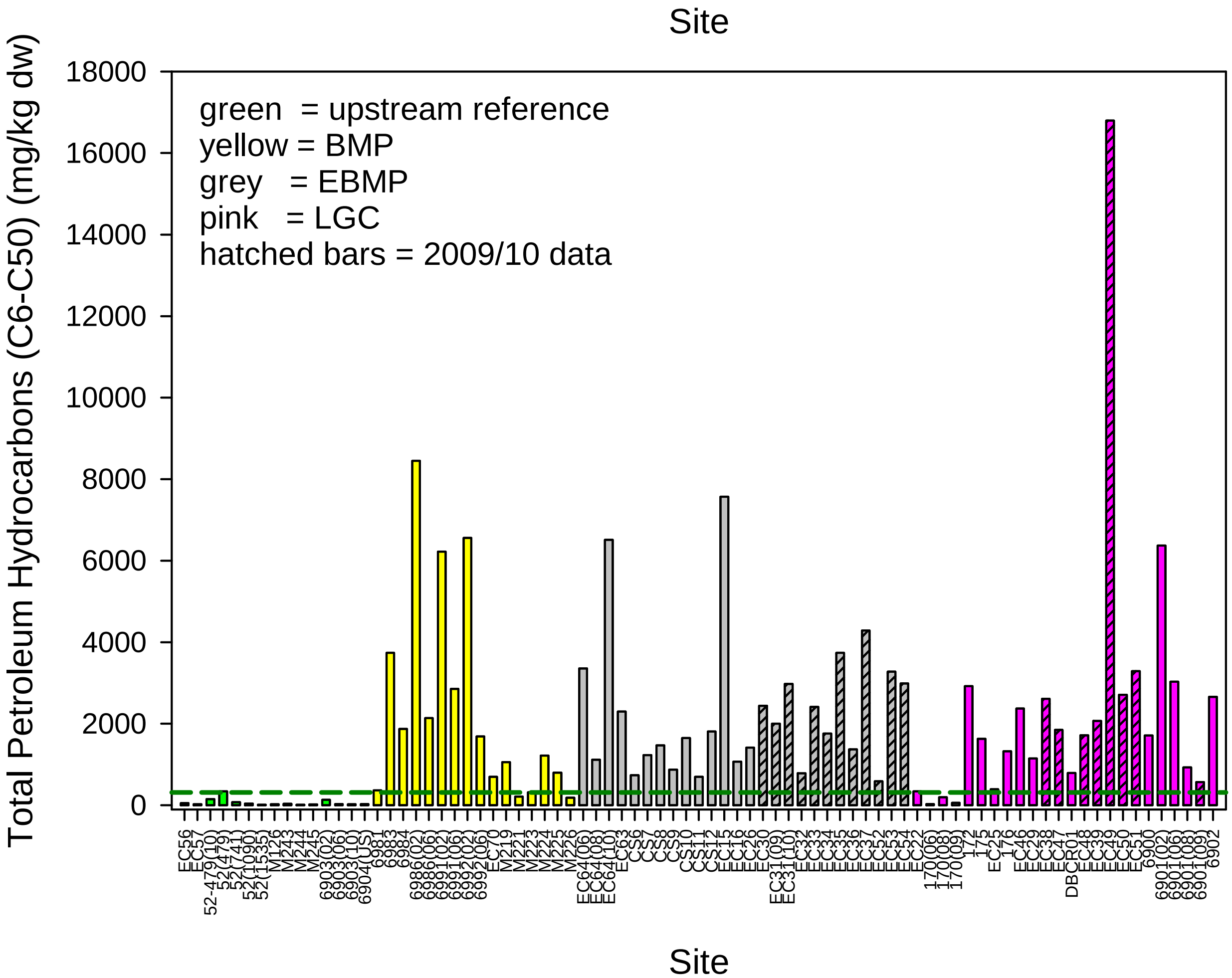


Figure 7. Total petroleum hydrocarbon concentration (mg/kg dw) in St. Marys River sediment for 2002 to 2010. Bars are colour coded for each area of the river. The green dashed line represents the upper 99th percentile concentration for upstream reference sites.

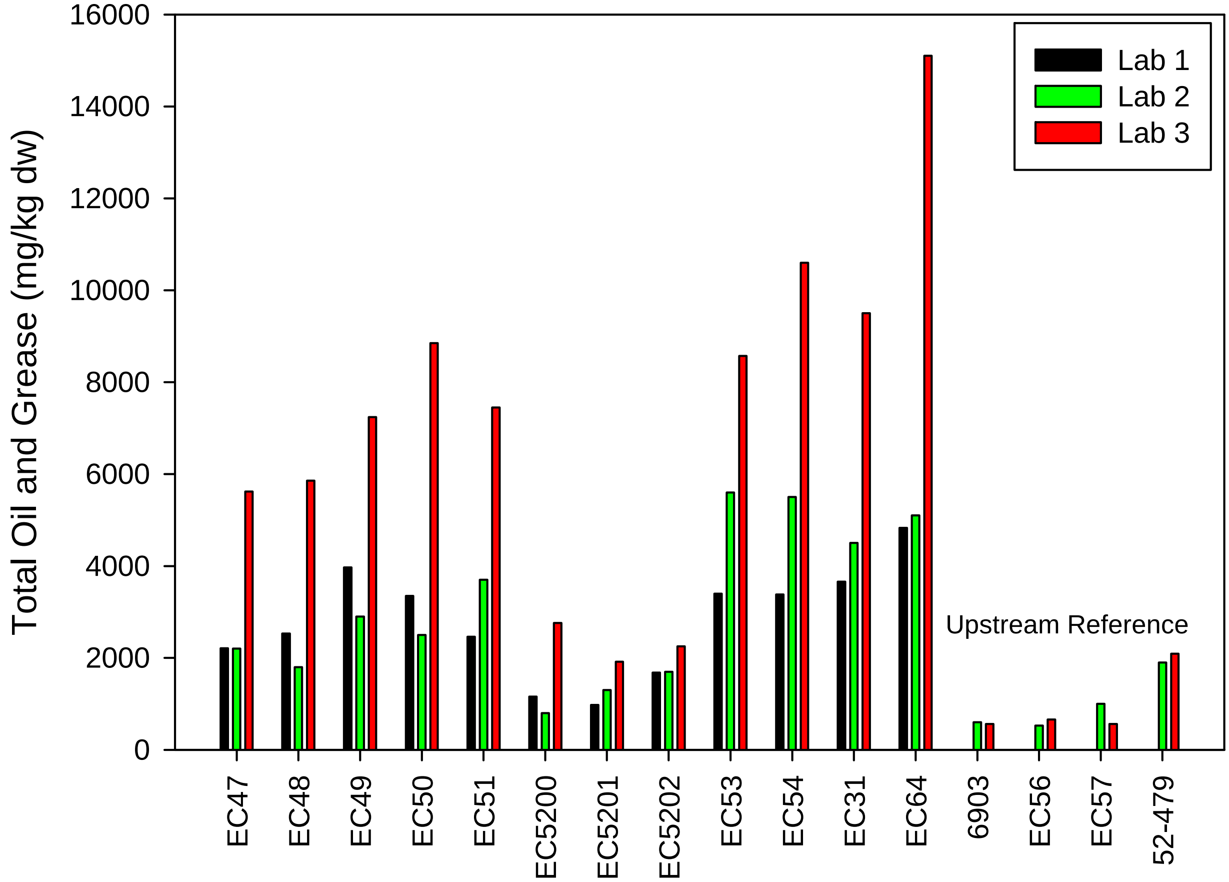


Figure 8. Total oil and grease concentration for split sediment samples for 2010.

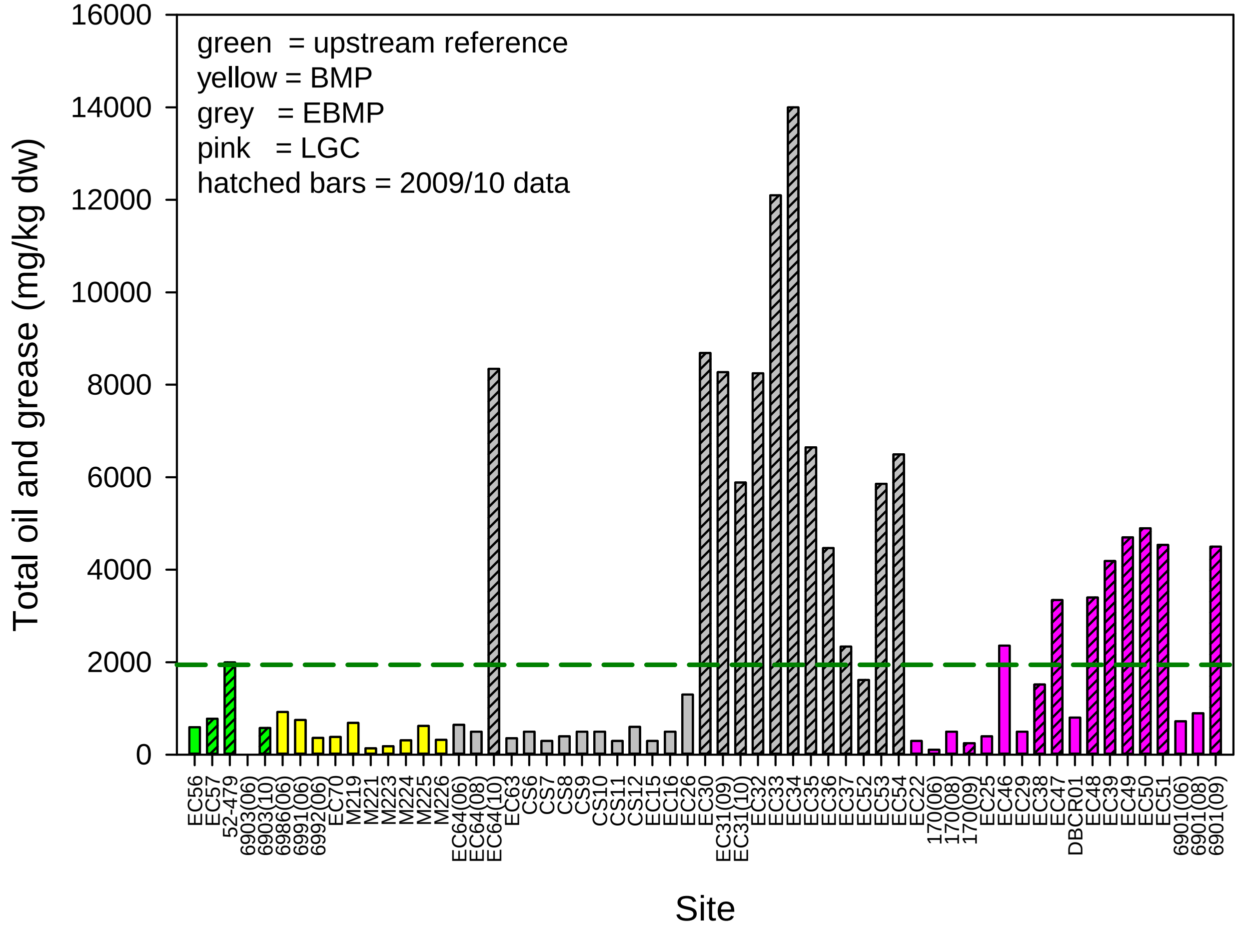


Figure 9. Oil and grease concentration (mg/kg dw) in St. Marys River sediment for 2002 to 2010. Bars are colour coded for each area of the river. The green dashed line represents the upper 99th percentile concentration for upstream reference sites.

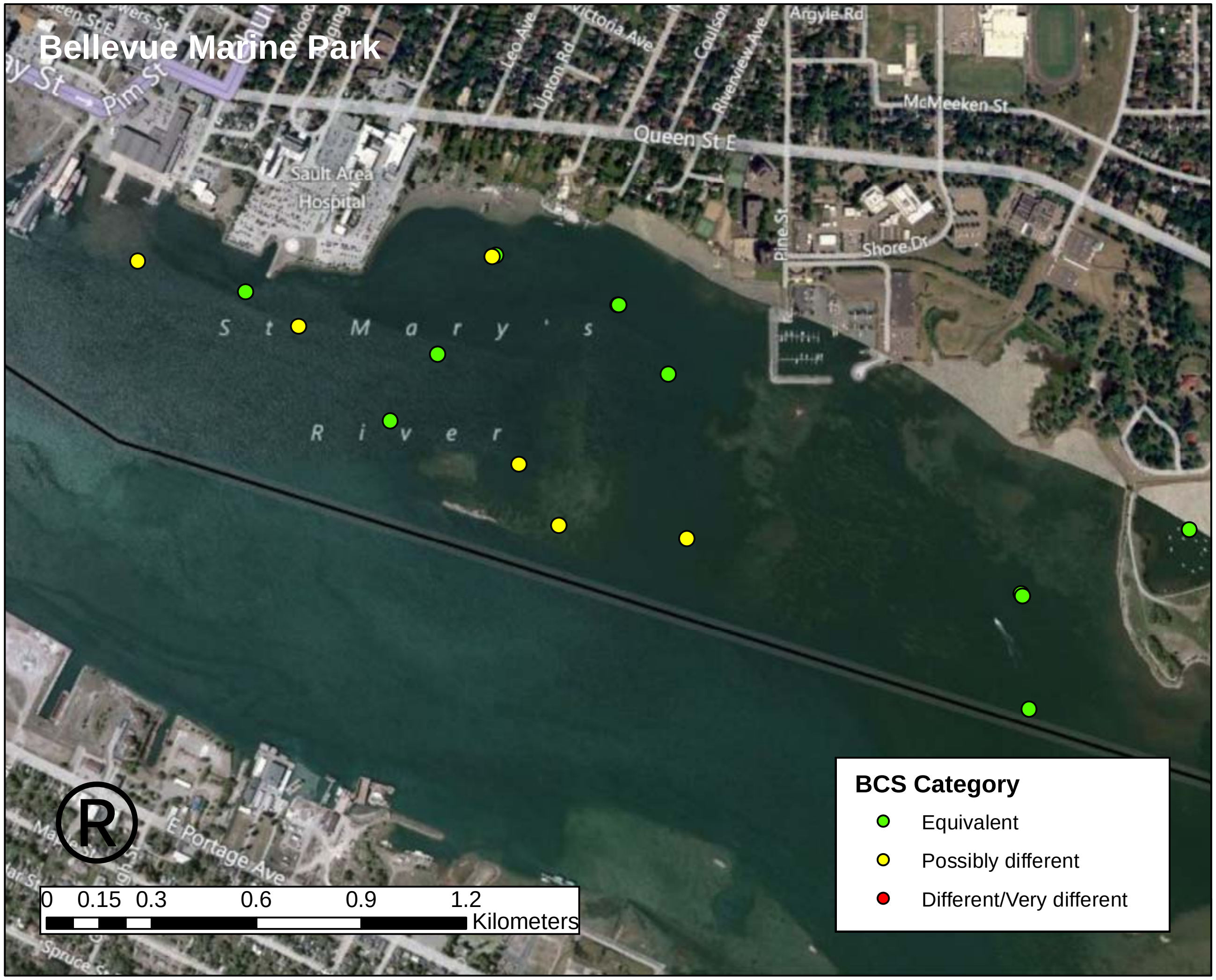


Figure 10a. BEAST benthic community categories at Bellevue Marine Park for 2002 to 2006.

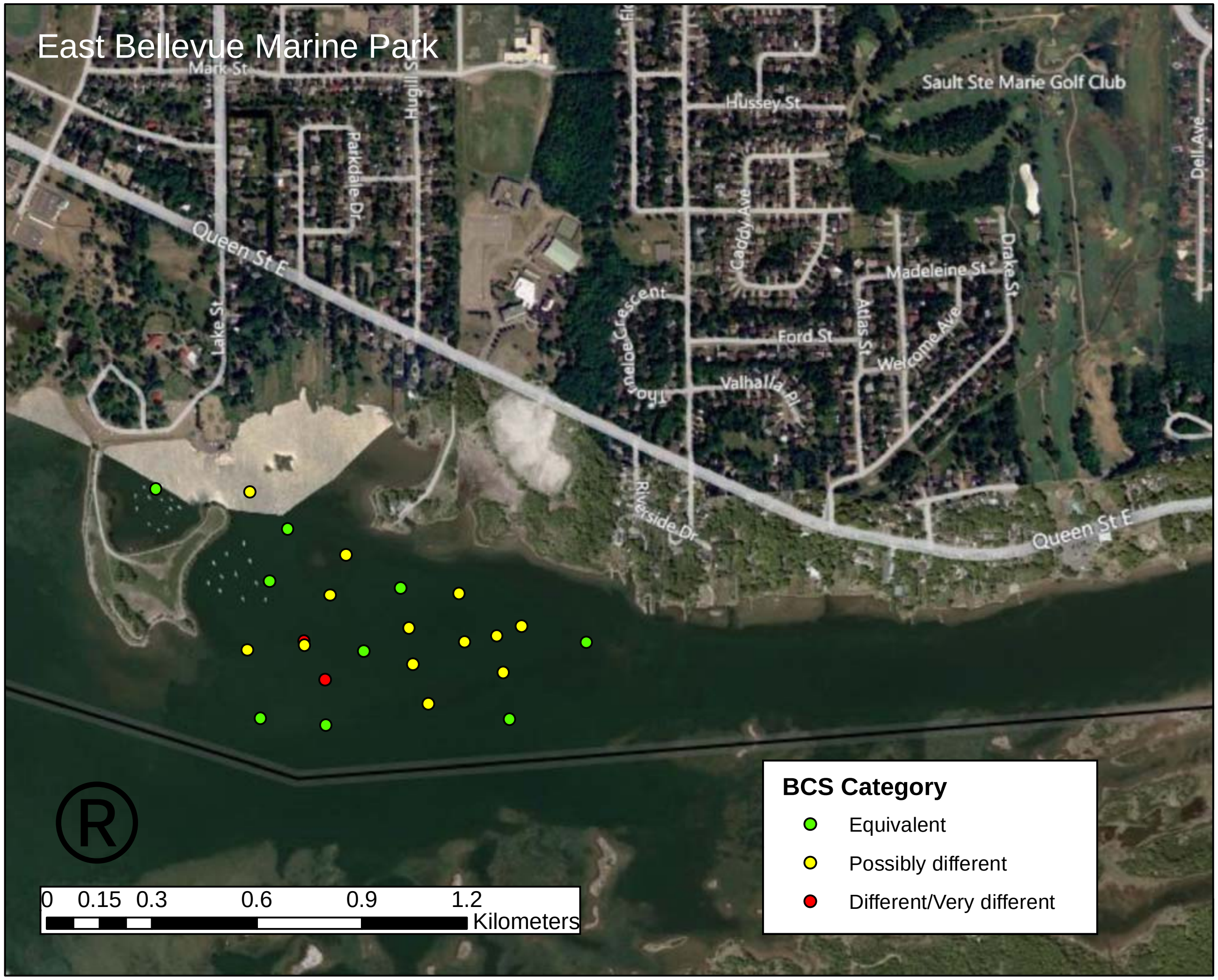


Figure 10b. BEAST benthic community categories at East Bellevue Marine Park for 2006 to 2010.

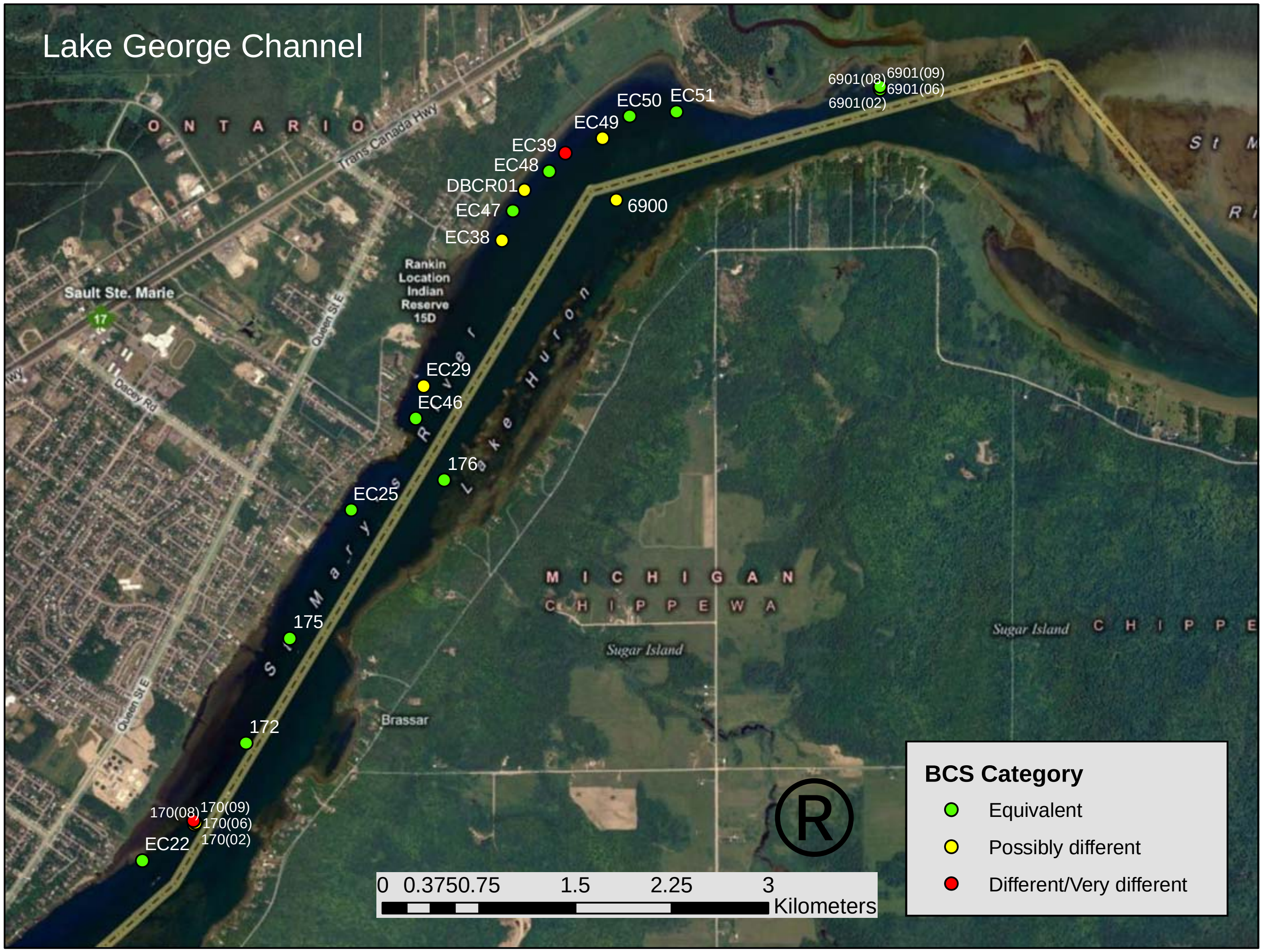


Figure 10c. BEAST benthic community categories in Lake George Channel for 2002 to 2010.

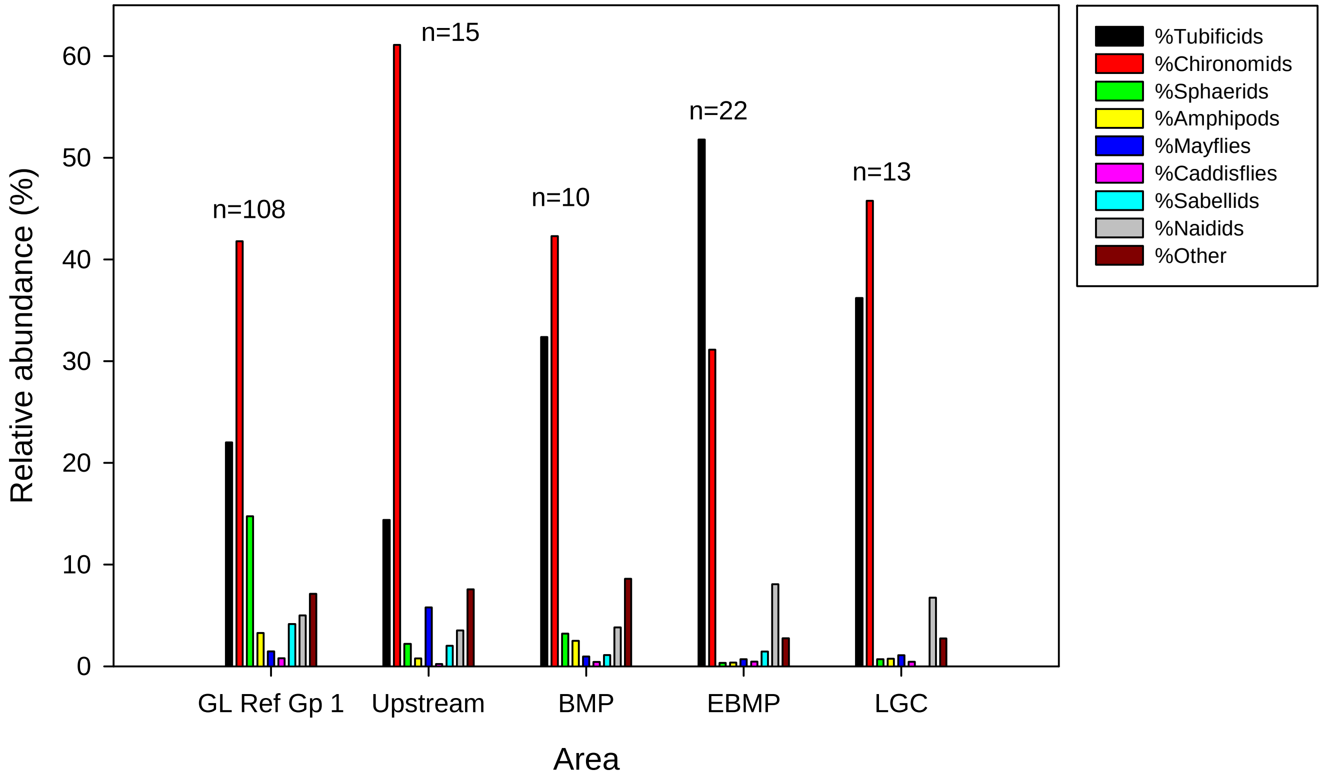


Figure 11. Relative abundances of key invertebrate taxa in the St. Marys River for 2002 to 2010. BMP= Bellevue Marine Park; EBMP = East Bellevue Marine Park; LGC = Lake George Channel

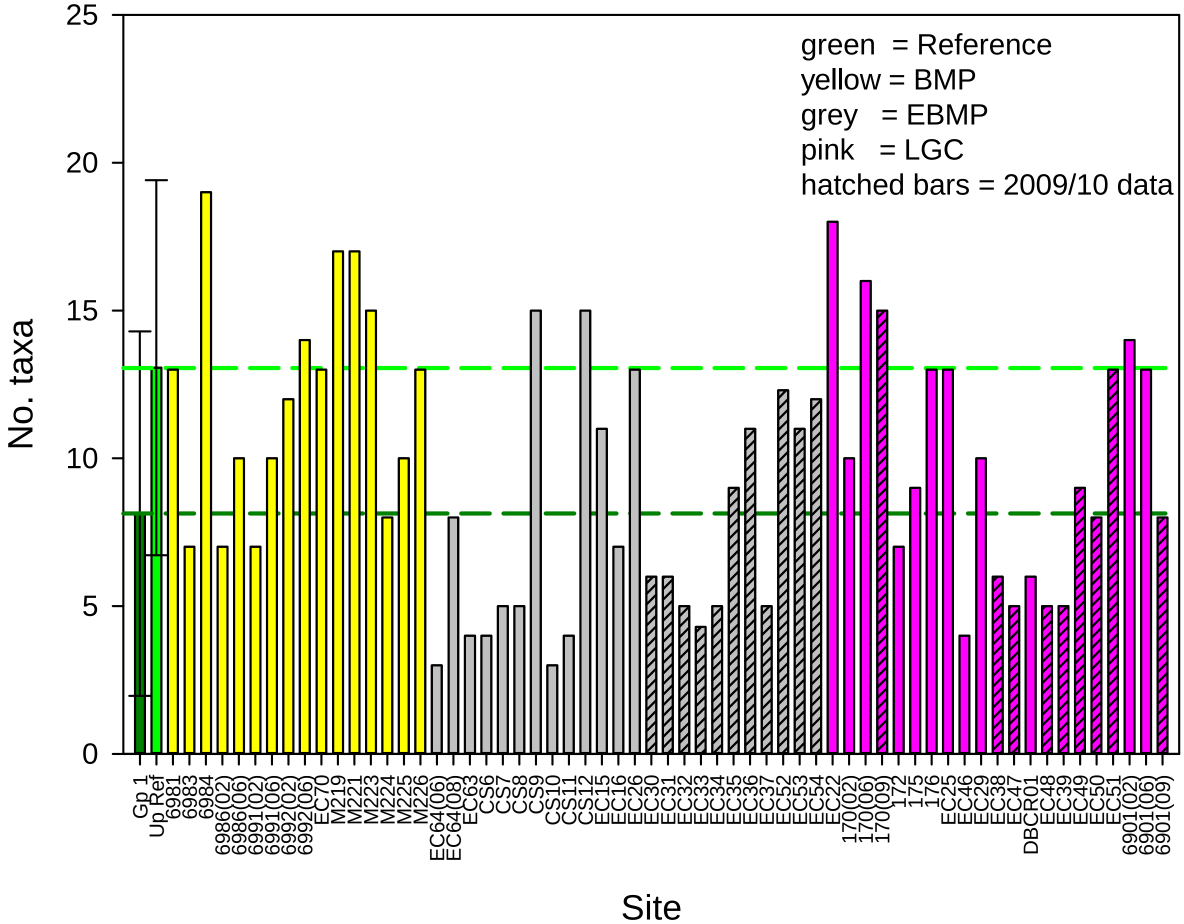


Figure 12. Benthic invertebrate taxon diversity for St. Marys River sites sampled in 2002 to 2010. Bars are colour coded for each area of the river. The error bars for (Great Lakes) Gp 1 (dark green bar) and upstream reference (light green bar) sites represent ± two standard deviations from the mean.

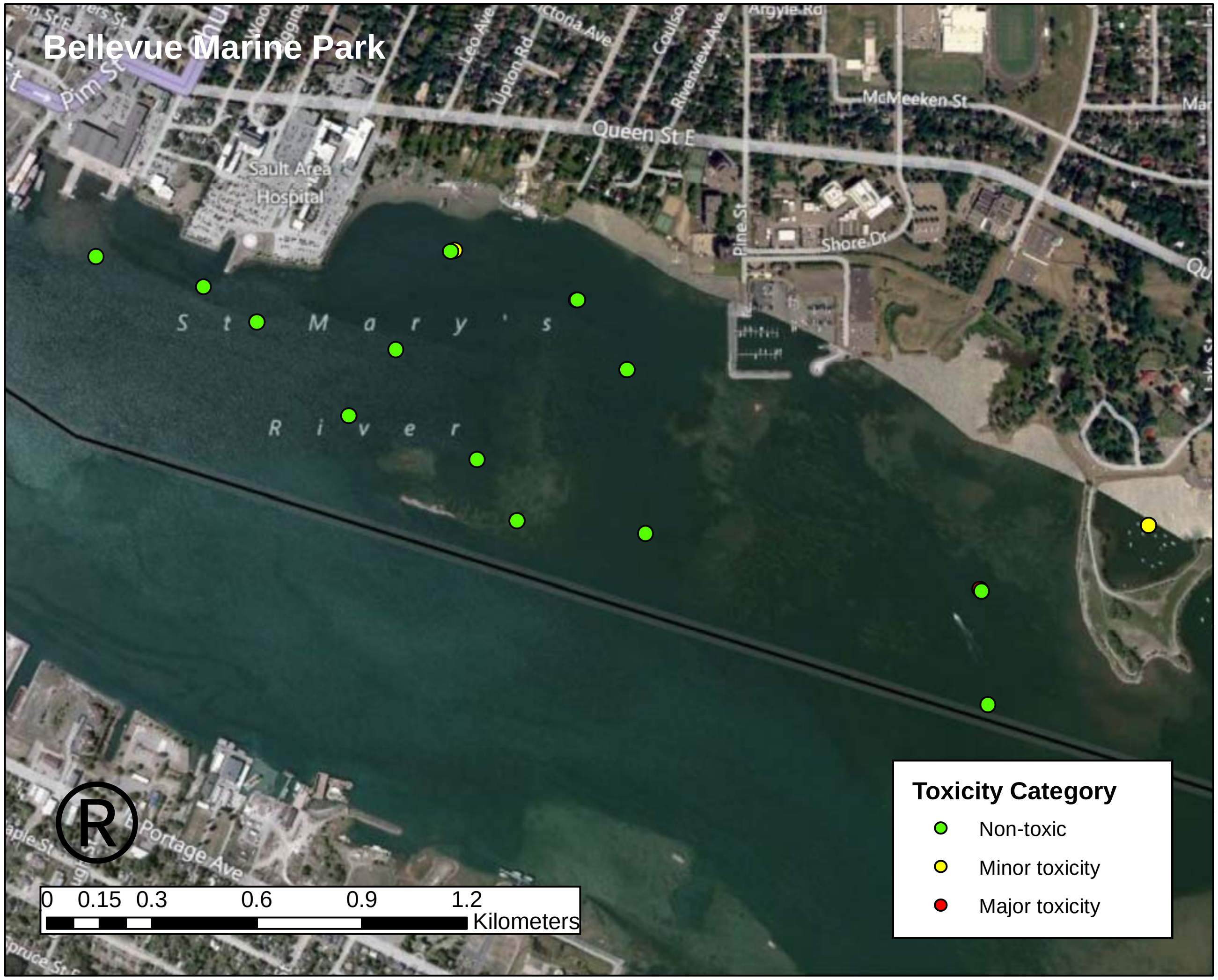


Figure 13a. Sediment decision-making framework toxicity categories for sites at Bellevue Marine Park for 2002 to 2006.

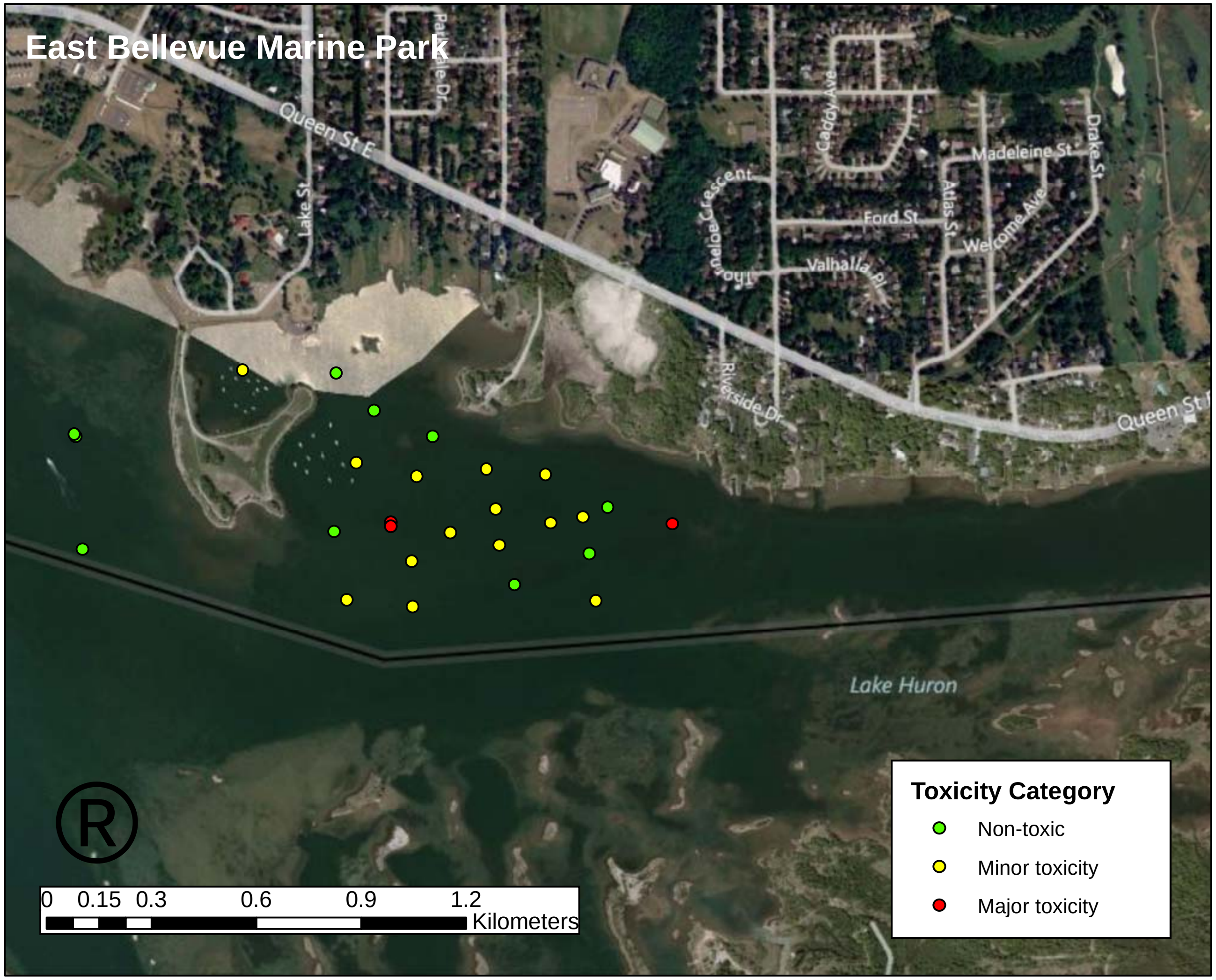


Figure 13b. Sediment decision-making framework toxicity categories for sites at East Bellevue Marine Park for 2006 to 2010.

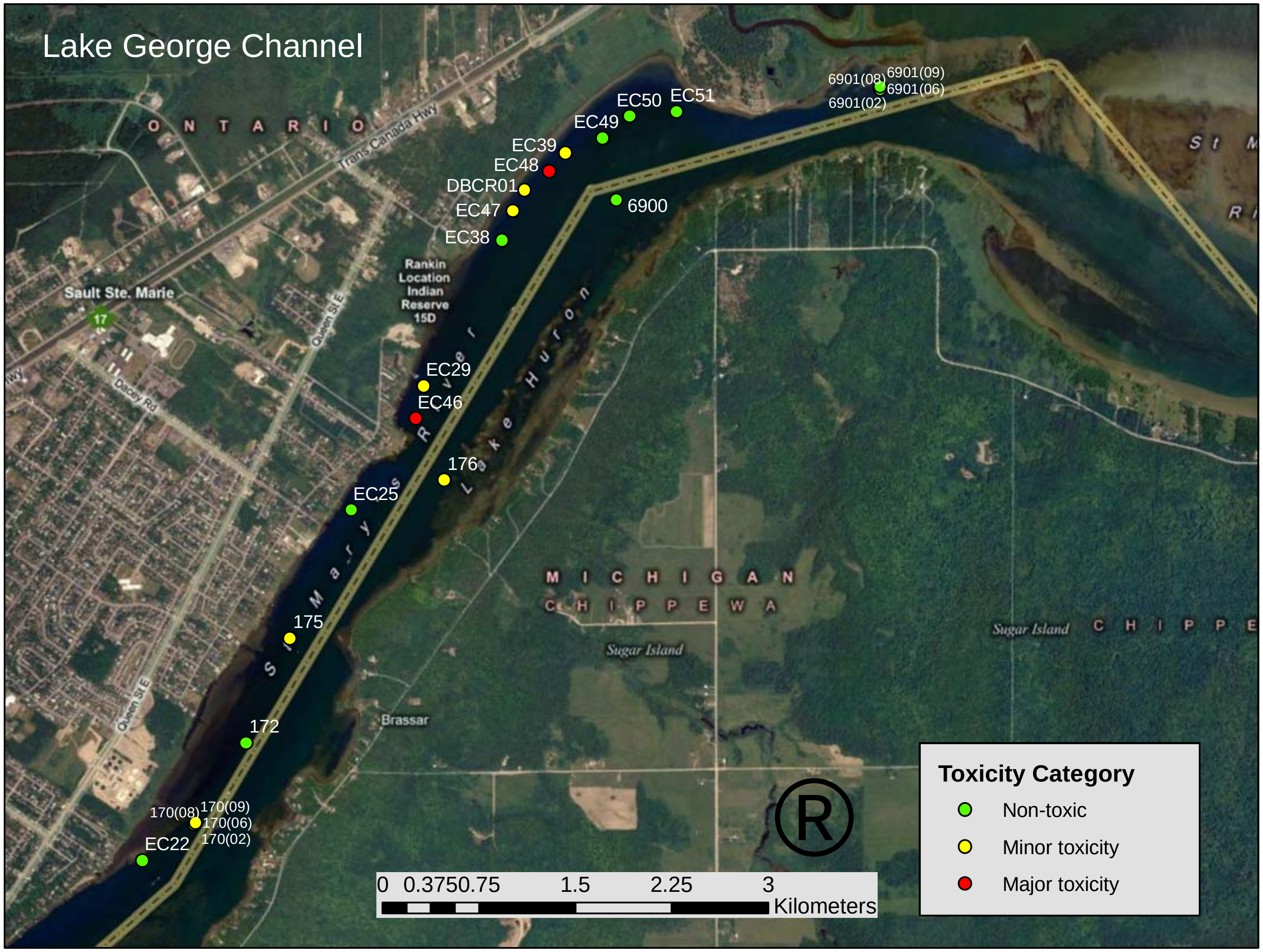


Figure 13c. Sediment decision-making framework toxicity categories for sites in Lake George Channel for 2002 to 2010.

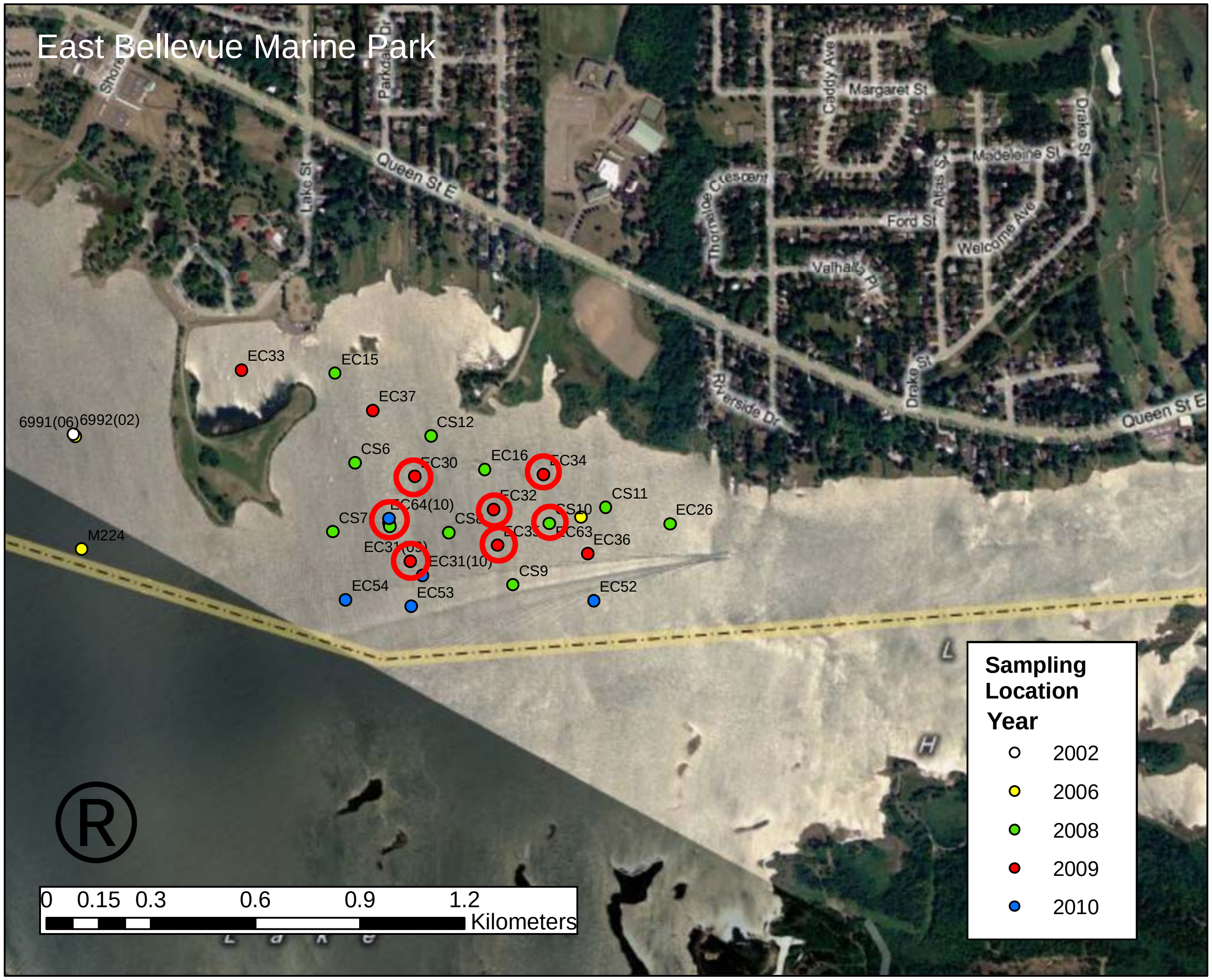


Figure 14a. Location of East Bellevue Marine Park sites requiring management actions (n=7; circled).

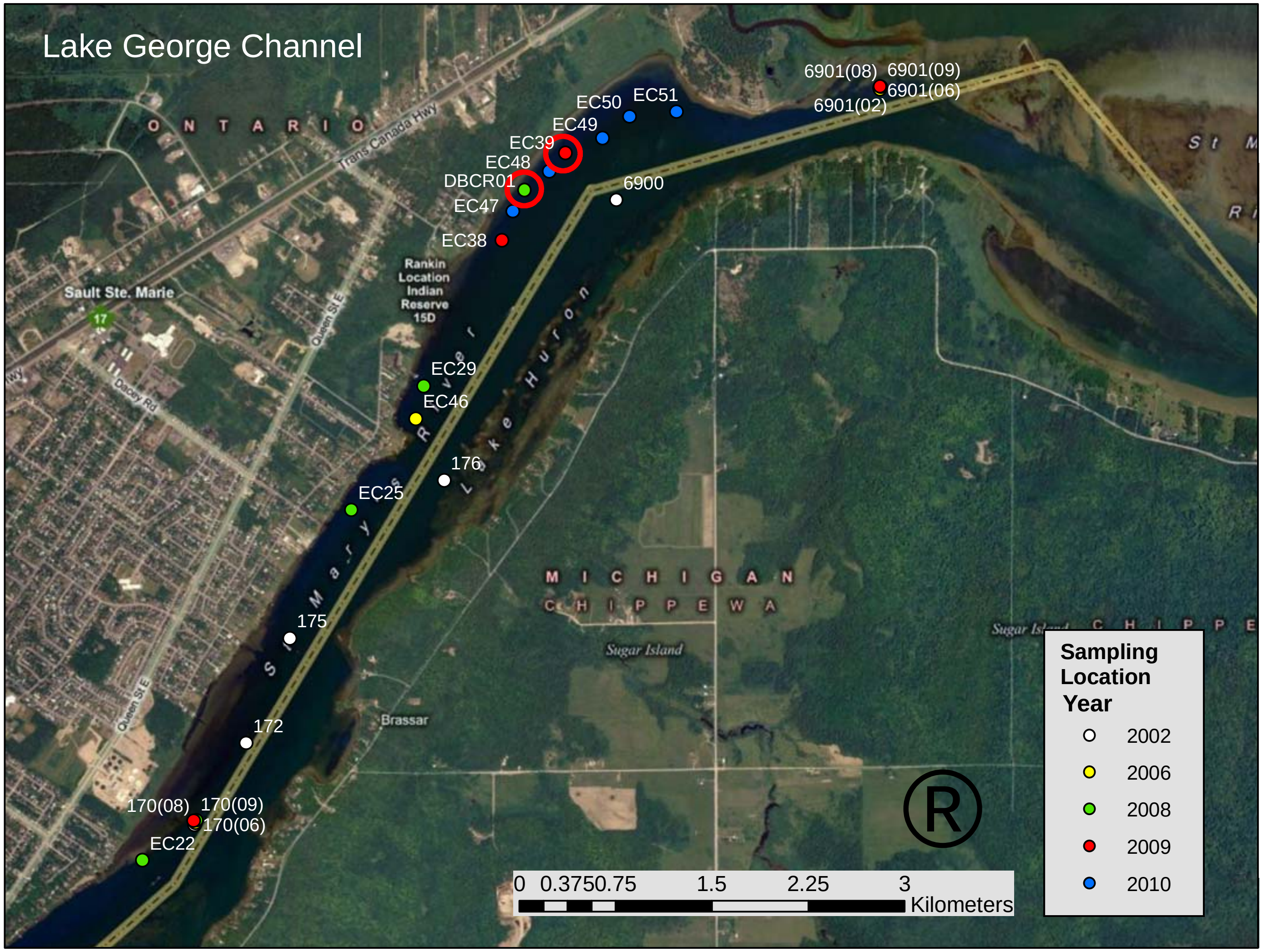


Figure 14b. Location of Lake George Channel sites requiring management actions (n=2; circled).

Appendix A: QA/QC Results for 2009-2010

Table A1. Coefficient of variation (CV) for trace metals and nutrients in field-replicated samples and relative percent difference (RPD) for laboratory duplicates for 2009-2010 (Caduceon Environmental Laboratory data). “<” = below method detection limit.

Parameter	Units	M.D.L.	EC3300	EC3301	EC3301 - Dup	R.P.D.	EC3302	CV	EC54	EC54 - Dup	R.P.D.	EC5200	EC5201	EC5202	CV
Aluminum	µg/g	10	12000	12000	12000	**0.0**	12000	**0.0**	6590	7180	**8.6**	2710	2210	2730	**11.6**
Antimony	µg/g	0.5	1.6	1.4	1.4	**0.0**	1.4	**7.9**	0.8	0.8	**0.0**	< 0.5	< 0.5	0.9	**-**
Arsenic	µg/g	0.5	10.8	10.3	10.4	**1.0**	10.2	**3.1**	8.5	9.2	**7.9**	3.9	3.9	4.6	**9.8**
Barium	µg/g	1	68	68	67	**1.5**	65	**2.6**	44	48	**8.7**	13	12	13	**4.6**
Beryllium	µg/g	0.2	0.6	0.6	0.6	**0.0**	0.6	**0.0**	0.3	0.4	**28.6**	< 0.2	< 0.2	< 0.2	**-**
Bismuth	µg/g	5	< 5	< 5	< 5	**0.0**	< 5	**-**	< 5	< 5	**0.0**	< 5	< 5	< 5	**-**
Cadmium	µg/g	0.5	1.6	1.6	1.7	**6.1**	1.6	**0.0**	0.8	0.8	**0.0**	< 0.5	< 0.5	< 0.5	**-**
Calcium	µg/g	10	4240	4170	4210	**1.0**	4270	**1.2**	3970	4220	**6.1**	1840	1660	1810	**5.4**
Chromium	µg/g	1	82	76	77	**1.3**	81	**4.0**	58	59	**1.7**	34	29	45	**22.7**
Cobalt	µg/g	1	11	11	12	**8.7**	11	**0.0**	17	15	**12.5**	8	8	8	**0.0**
Copper	µg/g	1	85	86	88	**2.3**	84	**1.2**	53	58	**9.0**	16	14	16	**7.5**
Iron	µg/g	10	61000	56500	57000	**0.9**	61000	**4.4**	51800	51100	**1.4**	32500	26900	30300	**9.4**
Lead	µg/g	5	175	156	161	**3.2**	158	**6.4**	56	64	**13.3**	21	20	27	**16.7**
Magnesium	µg/g	10	4400	4440	4520	**1.8**	4450	**0.6**	3260	3520	**7.7**	1260	1150	1230	**4.7**
Manganese	µg/g	1	592	568	579	**1.9**	598	**2.7**	460	460	**0.0**	232	234	229	**1.1**
Mercury	µg/g	0.005	0.292	0.330	0.323	**2.1**	0.329	**6.8**	0.130	0.138	**6.0**	0.100	0.069	0.106	**21.7**
Molybdenum	µg/g	1	2.000	2.000	1.000	**66.7**	1.000	**34.6**	2.000	2.000	**0.0**	< 1	< 1	< 1	**-**
Nickel	µg/g	1	30	29	29	**0.0**	30	**1.9**	23	24	**4.3**	10	11	11	**5.4**
Phosphorus	µg/g	5	715	698	713	**2.1**	695	**1.5**	578	596	**3.1**	342	361	360	**3.0**
Potassium	µg/g	30	1110	1140	1130	**0.9**	1130	**1.4**	820	870	**5.9**	310	290	290	**3.9**
Silicon	µg/g	1	236	193	173	**10.9**	205	**10.5**	96	93	**3.2**	143	136	134	**3.4**
Silver	µg/g	0.2	0.6	0.6	0.7	**15.4**	0.8	**17.3**	0.3	0.3	**0.0**	< 0.2	< 0.2	< 0.2	**-**
Sodium	µg/g	20	180	190	180	**5.4**	190	**3.1**	820	730	**11.6**	730	500	660	**18.7**
Strontium	µg/g	1	23	19	19	**0.0**	20	**10.1**	12	13	**8.0**	6	5	6	**10.2**
Tin	µg/g	10	10	< 10	< 10	**0.0**	10	**0.0**	< 10	< 10	**0.0**	< 10	< 10	< 10	**-**
Titanium	µg/g	1	562	556	536	**3.7**	559	**0.5**	394	406	**3.0**	249	224	236	**5.3**
Vanadium	µg/g	1	37	35	35	**0.0**	35	**3.2**	28	29	**3.5**	15	13	14	**7.1**
Yttrium	µg/g	0.5	8.9	8.8	8.7	**1.1**	8.8	**0.7**	7.6	8.2	**7.6**	5.0	4.7	5.3	**6.0**
Zinc	µg/g	1	458	450	465	**3.3**	451	**1.0**	202	220	**8.5**	65	63	70	**5.5**
Zirconium	µg/g	0.1	< 0.1	< 0.1	< 0.1	**0.0**	< 0.1	**-**	2.0	2.1	**4.9**	1.4	1.5	1.4	**4.0**
Aluminum (Al2O3)	%	0.01	7.48	7.27	7.39	**1.6**	7.39	**1.4**	8.3	8.3	**0.0**	6.8	7.2	7.0	**2.9**
Barium (BaO)	%	0.001	0.030	0.030	0.030	**0.0**	0.03	**0.0**	0.05	0.05	**0.0**	0.06	0.07	0.06	**9.1**
Calcium (CaO)	%	0.01	< 0.01	< 0.01	< 0.01	**0.0**	< 0.01	**-**	1.5	1.50	**0.0**	1.0	1.0	1.0	**0.0**
Chromium (Cr2O3)	%	0.01	0.06	< 0.01	0.04	**0.0**	0.04	**28.3**	0.03	0.04	**28.6**	0.07	0.03	0.06	**39.0**
Iron (Fe2O3)	%	0.05	7.25	6.53	6.65	**1.8**	6.93	**5.2**	7.7	7.9	**2.6**	5.1	4.8	5.6	**7.8**
Magnesium (MgO)	%	0.01	0.60	0.63	0.76	**18.7**	0.73	**10.4**	1.0	1.1	**9.5**	0.5	0.5	0.6	**10.8**
Manganese (MnO)	%	0.01	0.08	0.06	0.06	**0.0**	0.08	**15.7**	0.06	0.06	**0.0**	0.03	0.03	0.03	**0.0**
Phosphorus (P2O5)	%	0.03	< 0.03	< 0.03	< 0.03	**0.0**	< 0.03	**-**	< 2	< 2	**0.0**	< 2	< 2	< 2	**-**
Potasium (K20)	%	0.01	1.2	1.24	1.08	**13.8**	1.20	**1.9**	1.8	1.80	**0.0**	2.2	2.3	2.4	**4.3**
Silica (SiO2)	%	0.01	39.8	37.2	36.8	**1.1**	37.9	**3.5**	53.4	52.9	**0.9**	57.1	61.3	58.9	**3.6**
Sodium (Na2O)	%	0.01	< 0.01	< 0.01	< 0.01	**0.0**	< 0.01	**-**	< 3	< 3	**0.0**	< 3	< 3	< 3	**-**
Titanium (TiO2)	%	0.01	0.40	0.38	0.38	**0.0**	0.38	**3.0**	0.5	0.4	**22.2**	0.3	0.3	0.3	**0.0**
Loss on Ignition	%	0.05	14.9	15.8	16	**1.3**	16.3	**4.5**	13.9	14.8	**6.3**	4.32	4.32	5.63	**15.9**
Whole Rock Total	%		71.8	69	69.2	**0.0**	71	**1.9**	90.0	90.6	**0.7**	79.2	83.5	83.1	**2.9**
Total Organic Carbon	% by wt	0.1	7.3	7.3	7.5	**2.7**	7.3	**0.0**	6.2	6.2	**0.0**	2.3	3.4	3.3	**20.3**
Total Kjeldahl Nitrogen	µg/g	0.05	4270	3910	3970	**1.5**	4720	**9.4**	4020	3880	**3.5**	656	700	700	**3.7**
Phosphorus-Total	µg/g	0.01	751	715	714	**0.1**	807	**6.1**	700	660	**5.9**	529	419	403	**15.2**
					Min	**0.0**		**0.0**			**0.0**				**0.0**
					Max	**66.7**		**34.6**			**28.6**				**39.0**
					Median	**1.1**		**2.8**			**3.5**				**5.5**

Table A2. Coefficients of variation (CV) for organic contaminants in field-replicated sample for 2009. (ALS Laboratory Group data). “<” = below method detection limit.

Sample ID Date Sampled	**EC3300** **06-OCT-09**	**EC3301** **06-OCT-09**	**EC3302** **06-OCT-09**	**Mean**	**SD**	**CV**
Physical Tests						
% Moisture	71.0	70.3	70.0	70.4	0.5	0.7
Aggregate Organics						
Oil and Grease, Total	11000	12700	12600	12100	954	7.9
Volatile Organic Compounds						
Benzene	<0.050	<0.050	<0.050	-	-	-
Ethyl Benzene	<0.050	<0.050	<0.050	-	-	-
Toluene	<0.050	0.051	<0.050	0.1	-	-
o-Xylene	<0.050	<0.050	<0.050	-	-	-
m+p-Xylenes	<0.10	<0.10	<0.10	-	-	-
Xylene, (total)	<0.15	<0.15	<0.15	-	-	-
Hydrocarbons						
F1 (C6-C10)	<5.0	<5.0	<5.0	-	-	-
F1-BTEX	<5.0	<5.0	<5.0	-	-	-
F2 (C10-C16)	<30	<30	<30	-	-	-
F2-Naphth	<30	<30	<30	-	-	-
F3 (C16-C34)	1510	1350	1500	1453	90	6.2
F3-PAH	1490	1330	1480	1433	90	6.3
F4 (C34-C50)	1000	900	980	960	53	5.5
F4G-SG (GHH-Silica)	3410	6100	2740	4083	1778	43.6
Total Hydrocarbons (C6-C50)	2510	2250	2480	2413	142	5.9
Polycyclic Aromatic Hydrocarbons						
Acenaphthene	0.12	0.11	<0.10	0.12	0.01	6.1
Acenaphthylene	0.96	0.77	0.66	0.80	0.15	19.1
Acridine	<1.6	<1.6	<1.6	-	-	-
Anthracene	0.63	0.57	0.48	0.56	0.08	13.5
Benzo(a)anthracene	2.71	2.40	2.01	2.37	0.35	14.8
Benzo(a)pyrene	2.97	2.60	2.20	2.59	0.39	14.9
Benzo(b)fluoranthene	3.30	3.02	2.52	2.95	0.40	13.4
Benzo(g,h,i)perylene	2.01	1.80	1.53	1.78	0.24	13.5
Benzo(k)fluoranthene	2.00	1.78	1.56	1.78	0.22	12.4
Chrysene	2.68	2.37	1.98	2.34	0.35	15.0
Dibenzo(ah)anthracene	0.42	0.37	0.33	0.37	0.05	12.1
Fluoranthene	3.56	3.28	2.65	3.16	0.47	14.7
Fluorene	0.18	0.22	0.18	0.19	0.02	11.9
Indeno(1,2,3-cd)pyrene	2.78	2.51	2.13	2.47	0.33	13.2
1-Methylnaphthalene	<0.10	0.11	<0.10	0.11	-	-
2-Methylnaphthalene	0.19	0.20	0.18	0.19	0.01	5.3
Naphthalene	1.28	1.11	1.17	1.19	0.09	7.3
Phenanthrene	1.23	1.19	0.996	1.14	0.13	11.0
Pyrene	3.15	2.85	2.34	2.78	0.41	14.7
Quinoline	<0.10	<0.10	<0.10	-	-	-
Polychlorinated Biphenyls						
Aroclor 1242	<0.10	<0.10	<0.10	-	-	-
Aroclor 1248	<0.10	<0.10	<0.10	-	-	-
Aroclor 1254	<0.10	<0.10	<0.10	-	-	-
Aroclor 1260	<0.10	<0.10	<0.10	-	-	-
Total PCBs	0.14	<0.10	<0.10	0.14	-	-
					Min	**0.7**
					Max	**43.6**
					Median	**12.2**

Table A3. Coefficients of variation (CV) for organic contaminants in field-replicated sample for 2010. (ALS Laboratory Group data). "<" = below method detection limit.

Sample ID	EC5200	EC5201	EC5202	CV
Date Sampled	28-OCT-10	28-OCT-10	28-OCT-10	
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	0.146	0.348	0.253	40.6
Acenaphthylene	0.364	0.455	0.602	25.4
Acridine	0.080	0.137	0.136	27.7
Anthracene	0.533	1.30	0.888	42.3
Benz(a)anthracene	1.41	2.50	2.75	32.1
Benzo(a)pyrene	0.89	1.53	1.85	34.3
Benzo(b&j)fluoranthene	1.44	2.39	2.76	31.0
Benzo(e)pyrene	0.69	1.14	1.30	30.3
Benzo(g,h,i)perylene	0.758	1.01	1.16	20.8
Benzo(k)fluoranthene	0.585	0.904	0.97	25.1
Biphenyl	0.094	0.149	0.125	22.5
C2 sub'd B(a)A/chrysene	0.659	0.883	0.937	17.8
C2 Benzofluoranthenes/Benzopyrenes	0.414	0.518	0.651	22.5
C2 Biphenyls	0.048	0.081	0.066	25.4
C2 Dibenzothiophenes	0.223	0.355	0.330	23.2
C2 Fluoranthenes/Pyrenes	0.625	0.964	1.05	25.5
C2 Fluorenes	0.142	0.313	0.214	38.5
C2 Naphthalenes	0.694	1.17	0.951	25.4
C2 Phenanthrenes/Anthracenes	0.804	1.62	1.50	33.7
C3 Benzanthracenes/Chrysenes	0.350	0.308	0.401	13.2
C3 Dibenzothiophenes	0.295	0.468	0.416	22.6
C3 Fluoranthenes/Pyrenes	0.414	0.591	0.614	20.3
C3 Fluorenes	0.245	0.385	0.358	22.6
C3 Naphthalenes	0.549	0.892	0.735	23.7
C3 Phenanthrenes/Anthracenes	0.896	1.36	1.53	26.0
C4 Benzanthracenes/Chrysenes	0.079	0.076	0.103	17.2
C4 Dibenzothiophenes	0.311	0.434	0.394	16.5
C4 Fluoranthenes/Pyrenes	0.307	0.323	0.288	5.7
C4 Naphthalenes	0.355	0.526	0.559	22.8
C4 Phenanthrenes/Anthracenes	3.06	3.43	4.60	21.7
Chrysene	1.82	3.13	3.39	30.3
Dibenz(a,h)anthracene	0.213	0.345	0.404	30.5
Dibenzothiophene	0.111	0.219	0.156	33.5
Fluoranthene	2.43	4.58	4.19	30.7
Fluorene	0.221	0.454	0.332	34.7
Indeno(1,2,3-cd)pyrene	0.842	1.28	1.50	27.7
C1 Acenaphthenes	0.079	0.162	0.116	34.9
C1 Benz(a)Anthracenes/Chrysenes	0.920	1.49	1.61	27.5
C1 Benzofluoranthenes/Benzopyrenes	1.02	1.51	1.40	19.6
C1 Biphenyls	0.050	0.090	0.064	29.8
C1 Dibenzothiophenes	0.144	0.243	0.201	25.4
C1 Fluoranthenes/Pyrenes	1.21	2.18	2.25	30.9
C1 Fluorenes	0.102	0.233	0.175	38.6
C1 Phenanthrenes/Anthracenes	1.07	2.08	1.75	31.5
Retene	2.21	2.18	3.14	21.7
1-Methylnaphthalene	0.164	0.260	0.217	22.5
2-Methylnaphthalene	0.363	0.606	0.546	25.1
Naphthalene	3.84	5.94	5.23	21.3
Perylene	0.394	0.577	0.756	31.4
Phenanthrene	1.43	3.05	2.00	38.0
Pyrene	1.99	3.67	3.49	30.2
Quinoline	0.011	0.033	0.029	48.2

Sample ID	EC5200	EC5201	EC5202	CV
Date Sampled	28-OCT-10	28-OCT-10	28-OCT-10	
Physical Tests				
% Moisture	41.4	43.5	45.3	4.5
Aggregate Organics				
Oil and Grease, Total	2760	1920	2250	18.3
Volatile Organic Compounds				
Benzene	<0.050	<0.050	<0.050	-
Ethyl Benzene	<0.050	<0.050	<0.050	-
Toluene	<0.050	<0.050	<0.050	-
o-Xylene	<0.050	<0.050	<0.050	-
m+p-Xylenes	<0.10	<0.10	<0.10	-
Xylenes (Total)	<0.15	<0.15	<0.15	
Hydrocarbons				
F1 (C6-C10)	<5.0	<5.0	<5.0	-
F1-BTEX	<5.0	<5.0	<5.0	-
F2 (C10-C16)	15	14	11	15.6
F2-Naphth	13	12	<10	5.7
F3 (C16-C34)	524	340	328	27.6
F3-PAH	514	328	314	29.0
F4 (C34-C50)	188	190	161	9.0
F4G-SG (GHH-Silica)	710	640	510	16.4
Total Hydrocarbons (C6-C50)	727	544	500	20.4
Polychlorinated Biphenyls				
Aroclor 1242	<0.010	<0.010	<0.020	-
Aroclor 1248	<0.010	<0.010	<0.020	-
Aroclor 1254	<0.010	<0.010	<0.020	-
Aroclor 1260	<0.010	<0.010	<0.020	-
Total PCBs	<0.020	<0.020	<0.040	-

Min	**4.5**
Max	**48.2**
Median	**25.4**

Table A4. Sample recoveries for laboratory standards and reference material for 2009 (Caduceon Environmental Laboratory data).

QC I.D.:	Various	**CLIENT:**	Environment Canada
SAMPLE MATRIX:	Sediment	**BATCH NUMBER:**	B10-06193
DATE SUBMITTED:	11-Mar-10	**DATE ANALYZED:**	Various
DATE REPORTED:	4-May-10	**REPORT TO:**	Danielle Milani

PARAMETERS	**QC Sample Recovery Calculation**				
	Raw Data (µg/g)			**QC Sample Recovery**	
LKSD-3 (23-Mar-10)	**QC Result**	**Reference Value**	**Lab Mean**	**% Recovery**	**Control Limits**
Silver	2.5	2.4		**103**	50 - 117
Antimony	1.0	1.0		**100**	75 - 125
Arsenic	23.2	23		**101**	83 - 121
Barium	160	N/A	169	**95**	81 - 118
Beryllium	0.6	N/A	0.5	**120**	47 - 153
Cobalt	28.2	30		**94**	51 - 114
Chromium	48.1	51		**94**	54 - 125
Copper	32.3	34		**95**	79 - 116
Iron	28777	35000		**82**	74 - 102
Manganese	1200	1220		**98**	76 - 124
Molybdenum	0.59	2		**30**	0 - 260
Nickel	42.0	44.0		**95**	75 - 125
Lead	24	26		**92**	72 - 107
Strontium	25.7	N/A	25.4	**101**	76 - 124
Titanium	1040	N/A	980	**106**	49 - 151
Vanadium	48.9	55		**89**	63 - 113
Zinc	129	139		**93**	76 - 124
SS-1 (23-Mar-10)					
Silver	1.7	1.9		**89**	50 - 117
Aluminum	9210	9518		**97**	34 - 166
Arsenic	18	18		**100**	72 - 128
Barium	91.9	102		**90**	68 - 132
Cadmium	30.2	34		**89**	71 - 129
Cobalt	29.6	28		**106**	68 - 132
Chromium	44.3	64		**69**	20 - 180
Copper	725	690		**105**	73 - 127
Iron	19600	20406		**96**	62 - 138
Lithium	10.9	11		**99**	27 - 173
Magnesium	5963	6088		**98**	65 - 135
Manganese	398	425		**94**	76 - 124
Molybdenum	4.1	5		**82**	40 - 160
Nickel	212	231		**92**	68 - 132
Phosphorus	1102	1070		**103**	78 - 122
Lead	207	233		**89**	65 - 135
Strontium	183	202		**91**	84 - 116
Titanium	236	248		**95**	75 - 125
Vanadium	17.2	19		**91**	42 - 158
Yttrium	7.9	8		**99**	70 - 130
Zinc	6498	6775		**96**	75 - 125
LKSD-2 (23-Mar-10)					
Mercury	0.167	0.160	0.144	**104**	77 - 122

WH89-1 (01-Apr-10)					
Aluminum (Al2O3)	11.5	12.1	11.6	**95**	75 - 125
Barium (BaO)	0.27	0.29	0.28	**93**	75 - 125
Calcium (CaO)	4.76	5.9	5.7	**81**	75 - 125
Chromium (Cr2O3)	0.02	0.03	0.03	**67**	50 - 150
Iron (Fe2O3)	6.72	6.9	6.62	**97**	75 - 125
Magnesium (MgO)	2.97	3.5	3.4	**85**	75 - 125
Manganese (MnO)	0.09	0.14	0.13	**64**	60 - 140
Phosphorus (P2O5)	0.39	0.4	0.4	**98**	75 - 125
Potasium (K20)	2.12	2.5	2.2	**85**	75 - 125
Silica (SiO2)	55.6	60.5	59	**92**	75 - 125
Sodium (Na2O)	1.98	2.0		**99**	75 - 125
Titanium (TiO2)	0.83	1.0		**83**	75 - 125
D053-542 (16-Mar-10)					
Total Kjeldahl Nitrogen	1787	1300	1372	**130**	57 - 143
Phosphorus-Total	1087	811	939	**116**	53 - 147
TOC QC (03-Feb-10)					
TOC	4.60	4.84		**95**	91 - 109
			Min	**30**	
			Max	**130**	
			Median	**95**	

Table A5. Sample recoveries for laboratory standards and reference material for 2010 (Caduceon Environmental Laboratory data).

QC I.D.:	Various	**CLIENT:**	Environment Canada
SAMPLE MATRIX:	Sediment	**BATCH NUMBER:**	B10-36564
DATE SUBMITTED:	7-Dec-10	**DATE ANALYZED:**	Various
DATE REPORTED:	28-Jan-11	**REPORT TO:**	Danielle Milani

PARAMETERS	**QC Sample Recovery Calculation**				
	Raw Data (µg/g)			**QC Sample Recovery**	
LKSD-3 (13-Dec-10)	**QC Result**	**Reference Value**	**Lab Mean**	**% Recovery**	**Control Limits**
Silver	2.3	2.4		**96**	67 - 132
Antimony	0.8	1.0	0.95	**84**	63 - 137
Arsenic	22.5	23	23.9	**94**	68 - 132
Barium	153	N/A	153	**100**	83 - 117
Beryllium	0.6	N/A	0.6	**100**	83 - 117
Cadmium	0.5	0.6	0.6	**80**	23 - 177
Cobalt	33	30	34	**97**	75 - 125
Chromium	47	51		**92**	74 - 126
Copper	31	34	31	**100**	79 - 121
Iron	29200	35000	30724	**95**	74 - 126
Manganese	1190	1220		**98**	76 - 124
Molybdenum	< 1	2	0.7	**-**	2 - 198
Nickel	41.0	44.0		**93**	75 - 125
Lead	26	26	29.0	**90**	70 - 130
Strontium	24	N/A	23.5	**102**	77 - 123
Titanium	935	N/A	963	**97**	78 - 122
Vanadium	45	55	45.6	**99**	83 - 117
Zinc	121	139	134	**90**	60 - 140
LKSD-2 (13-Dec-10)					
Mercury	0.161	0.160	0.144	**101**	77 - 122

WH89-1 (07-Jan-11)					
Aluminum (Al2O3)	11.5	12.1	11.6	**95**	75 - 125
Barium (BaO)	0.28	0.29	0.28	**95**	75 - 125
Calcium (CaO)	5.27	5.9	5.7	**89**	75 - 125
Chromium (Cr2O3)	0.03	0.03	0.03	**106**	50 - 150
Iron (Fe2O3)	6.76	6.9	6.62	**98**	75 - 125
Magnesium (MgO)	3.16	3.5	3.4	**90**	75 - 125
Manganese (MnO)	0.09	0.14	0.13	**61**	60 - 140
Phosphorus (P2O5)	< 2	0.4	0.4	**-**	75 - 125
Potasium (K20)	1.9	2.5	2.2	**75**	70 - 130
Silica (SiO2)	56.4	60.5	59	**93**	75 - 125
Sodium (Na2O)	< 3	2.0		**-**	75 - 125
Titanium (TiO2)	0.85	1.0		**85**	75 - 125
D053-542 (10-Dec-10)					
Total Kjeldahl Nitrogen	1387	1300	1372	**101**	57 - 143
Phosphorus-Total	764	811	939	**81**	53 - 147
TOC QC (07-Jan-11)					
TOC	4.56	4.84		**94**	91 - 109
			Min	**61**	
			Max	**106**	
			Median	**95**	

Table A6. Percent recoveries in surrogate spiked samples for 2009-2010 (ALS Laboratory Group data).

	BTEX	Hydrocarbons	Polycyclic Aromatic Hydrocarbons		Polychlorinated Biphenyls
2009 Site	2,5-Dibromotoluene	Octacosane	2-Fluorobiphenyl	p-Terphenyl d14	d14-Terphenyl
EC30	91	98	101	112	107
EC31	89	98	97	111	105
EC32	93	106	99	112	103
EC3300	88	97	106	114	100
EC3301	92	92	110	119	98
EC3302	91	103	103	111	100
EC34	98	91	99	111	101
EC35	88	101	104	111	100
EC36	91	97	105	118	91
EC37	91	95	100	118	99
170	88	88	95	103	111
EC38	85	107	114	121	103
EC39	99	99	103	113	105
6901	91	102	95	106	101
Min	**85**	**88**	**95**	**103**	**91**
Max	**99**	**107**	**114**	**121**	**111**
Median	**91**	**98**	**102**	**112**	**101**

	Volatile Organic Compounds			Hydrocarbons		Polycyclic Aromatic Hydrocarbons						PCBs
2010 Site	4-Bromofluorobenzene	3,4-Dichloro-toluene	1,4-Difluoro-benzene	2-Bromobenzo-trifluoride	Octacosane	Acenaphthylene d8	Benzo(a) pyrene d12	Benzo(g,h,i)perylene d12	Naphthalene d8	Phenanthrene d10	Pyrene d10	d14-Terphenyl
EC47	72	74	74	95	104	105	153	77	91	107	105	102
EC48	73	75	75	101	110	109	161	79	90	109	107	102
EC49	72	72	73	83	121	105	164	81	91	107	102	98
EC50	73	72	74	70	110	103	167	87	87	106	105	103
EC51	78	78	80	77	109	107	158	83	92	103	108	86
EC5200	85	84	87	80	108	107	204	91	88	104	106	104
EC5201	83	82	84	85	113	110	191	97	92	109	112	100
EC5202	85	78	86	75	107	106	206	99	89	104	108	93
EC53	74	73	75	75	99	105	169	87	93	105	108	104
EC54	73	71	75	75	100	105	130	77	90	107	105	100
EC55	82	80	83	84	107	85	208	92	59	108	109	119
EC56	83	79	82	85	101	106	200	90	79	108	105	118
EC57	81	81	84	80	102	102	210	98	52	110	108	117
EC59	76	71	80	95	111	94	175	123	44	105	101	112
EC31	72	73	74	74	98	88	130	83	56	108	103	97
EC64	72	72	74	74	91	99	142	86	60	112	111	102
Min	**72**	**71**	**73**	**70**	**91**	**85**	**130**	**77**	**44**	**103**	**101**	**86**
Max	**85**	**84**	**87**	**101**	**121**	**110**	**210**	**123**	**93**	**112**	**112**	**119**
Median	**75**	**74.5**	**77.5**	**80**	**107**	**105**	**168**	**87**	**88.5**	**107**	**106.5**	**102**

Table A7. Reporting limits (mg/kg) for organic contaminant analyses for 2009 (ALS Laboratory Group data).

Sample ID	EC30	EC31	EC32	EC33	EC34	EC35	EC36	EC37	170	EC38	EC39	6901
Physical Tests												
% Moisture	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Aggregate Organics												
Oil and Grease, Total	500	500	500	500	500	500	500	500	500	500	500	500
Volatile Organic Compounds												
Benzene	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Ethyl Benzene	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Toluene	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
o-Xylene	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
m+p-Xylenes	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Xylene, (total)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Hydrocarbons												
F1 (C6-C10)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
F1-BTEX	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
F2 (C10-C16)	40	20	10	30	30	20	30	30	10	30	30	20
F2-Naphth	40	20	10	30	30	20	30	30	10	30	30	20
F3 (C16-C34)	200	100	50	150	150	100	150	150	50	150	150	100
F3-PAH	200	100	50	150	150	100	150	150	50	150	150	100
F4 (C34-C50)	200	100	50	150	150	100	150	150	50	150	150	100
F4G-SG (GHH-Silica)	500	500	500	500	500	500	500	500	500	500	500	500
Total Hydrocarbons (C6-C50)	200	100	50	150	150	100	150	150	50	150	150	100
Polycyclic Aromatic Hydrocarbons												
Acenaphthene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Acenaphthylene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Acridine	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	0.80	1.6	1.6	1.6
Anthracene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Benzo(a)anthracene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Benzo(a)pyrene	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.020	0.040	0.040	0.040
Benzo(b)fluoranthene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Benzo(g,h,i)perylene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Benzo(k)fluoranthene	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.020	0.040	0.040	0.040
Chrysene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Dibenzo(ah)anthracene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Fluoranthene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Fluorene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Indeno(1,2,3-cd)pyrene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
1-Methylnaphthalene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
2-Methylnaphthalene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Naphthalene	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.010	0.020	0.020	0.020
Phenanthrene	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.030	0.060	0.060	0.060
Pyrene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Quinoline	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Polychlorinated Biphenyls												
Aroclor 1242	0.10	0.10	0.10	0.10	0.10	0.15	0.10	0.10	0.050	0.10	0.10	0.10
Aroclor 1248	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Aroclor 1254	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Aroclor 1260	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10
Total PCBs	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.050	0.10	0.10	0.10

Table A8. Reporting limits (mg/kg) for organic contaminant analyses for 2010 (ALS Laboratory Group data).

Sample ID	EC47	EC48	EC49	EC50	EC51	EC52	EC53	EC54	EC55	EC56	EC57	EC59	EC31	EC64
Physical Tests														
% Moisture	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Aggregate Organics														
Oil and Grease, Total	864	864	288	288	288	288	288	288	288	288	288	576	288	288
Volatile Organic Compounds														
Benzene	0.050	0.15	0.15	0.20	0.15	0.050	0.15	0.15	0.050	0.050	0.050	0.10	0.15	0.15
Ethyl Benzene	0.050	0.15	0.15	0.20	0.15	0.050	0.15	0.15	0.050	0.050	0.050	0.10	0.15	0.15
Toluene	0.050	0.15	0.15	0.20	0.15	0.050	0.15	0.15	0.050	0.050	0.050	0.10	0.15	0.15
o-Xylene	0.050	0.15	0.15	0.20	0.15	0.050	0.15	0.15	0.050	0.050	0.050	0.10	0.15	0.15
m+p-Xylenes	0.10	0.30	0.30	0.40	0.30	0.10	0.30	0.30	0.10	0.10	0.10	0.20	0.30	0.30
Xylenes (Total)	0.15	0.34	0.34	0.45	0.34	0.15	0.34	0.34	0.15	0.15	0.15	0.22	0.34	0.34
Hydrocarbons														
F1 (C6-C10)	5.0	15	15	20	15	5.0	15	15	5.0	5.0	5.0	10	15	15
F1-BTEX	5.0	15	15	20	15	5.0	15	15	5.0	5.0	5.0	10	15	15
F2 (C10-C16)	30	30	40	40	30	10	30	40	10	10	10	20	40	40
F2-Naphth	30	30	40	40	30	10	30	40	10	10	10	20	40	40
F3 (C16-C34)	150	150	200	200	150	50	150	200	50	50	50	100	200	200
F3-PAH	150	150	200	200	150	50	150	200	50	50	50	100	200	200
F4 (C34-C50)	150	150	200	200	150	50	150	200	50	50	50	100	200	200
F4G-SG (GHH-Silica)	500	500	2000	2000	1500	500	2000	2000	500	500	500	1000	2000	2000
Total Hydrocarbons (C6-C50)	150	150	200	200	150	50	150	200	50	50	50	100	200	200
Polycyclic Aromatic Hydrocarbons														
Acenaphthene	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Acenaphthylene	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Acridine	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Anthracene	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Benz(a)anthracene	0.010	0.10	0.010	0.010	0.10	0.10	0.10	0.010	0.010	0.010	0.010	0.010	0.010	0.10
Benzo(a)pyrene	0.010	0.010	0.010	0.010	0.10	0.10	0.10	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Benzo(b&j)fluoranthene	0.010	0.10	0.10	0.10	0.10	0.10	0.10	0.010	0.010	0.010	0.010	0.010	0.10	0.10
Benzo(e)pyrene	0.010	0.010	0.010	0.010	0.10	0.10	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Benzo(g,h,i)perylene	0.010	0.010	0.010	0.010	0.10	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Benzo(k)fluoranthene	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Biphenyl	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
C2 sub'd B(a)A/chrysene	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C2 Benzofluoranthenes/Benzopyrenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C2 Biphenyls	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C2 Dibenzothiophenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C2 Fluoranthenes/Pyrenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C2 Fluorenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C2 Naphthalenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C2 Phenanthrenes/Anthracenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C3 Benzanthracenes/Chrysenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C3 Dibenzothiophenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C3 Fluoranthenes/Pyrenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C3 Fluorenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C3 Naphthalenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C3 Phenanthrenes/Anthracenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C4 Benzanthracenes/Chrysenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C4 Dibenzothiophenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C4 Fluoranthenes/Pyrenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C4 Naphthalenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C4 Phenanthrenes/Anthracenes	0.040	0.040	0.040	0.040	0.40	0.40	0.40	0.040	0.040	0.40	0.40	0.40	0.040	0.40
Chrysene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.010	0.010	0.010	0.010	0.010	0.10	0.10
Dibenz(a,h)anthracene	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Dibenzothiophene	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Fluoranthene	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.010	0.010	0.010	0.010	0.10	0.10
Fluorene	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Indeno(1,2,3-cd)pyrene	0.010	0.010	0.010	0.010	0.10	0.010	0.10	0.010	0.010	0.010	0.010	0.010	0.010	0.10
C1 Acenaphthenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C1 Benz(a)Anthracenes/Chrysenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C1 Benzofluoranthenes/Benzopyrenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C1 Biphenyls	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C1 Dibenzothiophenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C1 Fluoranthenes/Pyrenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C1 Fluorenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C1 Phenanthrenes/Anthracenes	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
Retene	0.010	0.010	0.010	0.010	0.010	0.10	0.10	0.010	0.010	0.10	0.10	0.10	0.010	0.010
1-Methylnaphthalene	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
2-Methylnaphthalene	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Naphthalene	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.050	0.050	0.050	0.050	0.50	0.50
Perylene	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Phenanthrene	0.010	0.010	0.010	0.010	0.10	0.10	0.10	0.010	0.010	0.010	0.010	0.010	0.010	0.10
Pyrene	0.010	0.10	0.010	0.10	0.10	0.10	0.10	0.010	0.010	0.010	0.010	0.010	0.10	0.10
Quinoline	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Polychlorinated Biphenyls														
Aroclor 1242	0.030	0.030	0.040	0.040	0.030	0.010	0.030	0.040	0.010	0.020	0.010	0.020	0.040	0.040
Aroclor 1248	0.030	0.030	0.040	0.040	0.030	0.010	0.030	0.040	0.010	0.020	0.010	0.020	0.040	0.040
Aroclor 1254	0.030	0.030	0.040	0.040	0.030	0.010	0.030	0.040	0.010	0.020	0.010	0.020	0.040	0.040
Aroclor 1260	0.030	0.030	0.040	0.040	0.030	0.010	0.030	0.040	0.010	0.020	0.010	0.020	0.040	0.040
Total PCBs	0.060	0.060	0.080	0.080	0.060	0.020	0.060	0.080	0.020	0.040	0.020	0.040	0.080	0.080

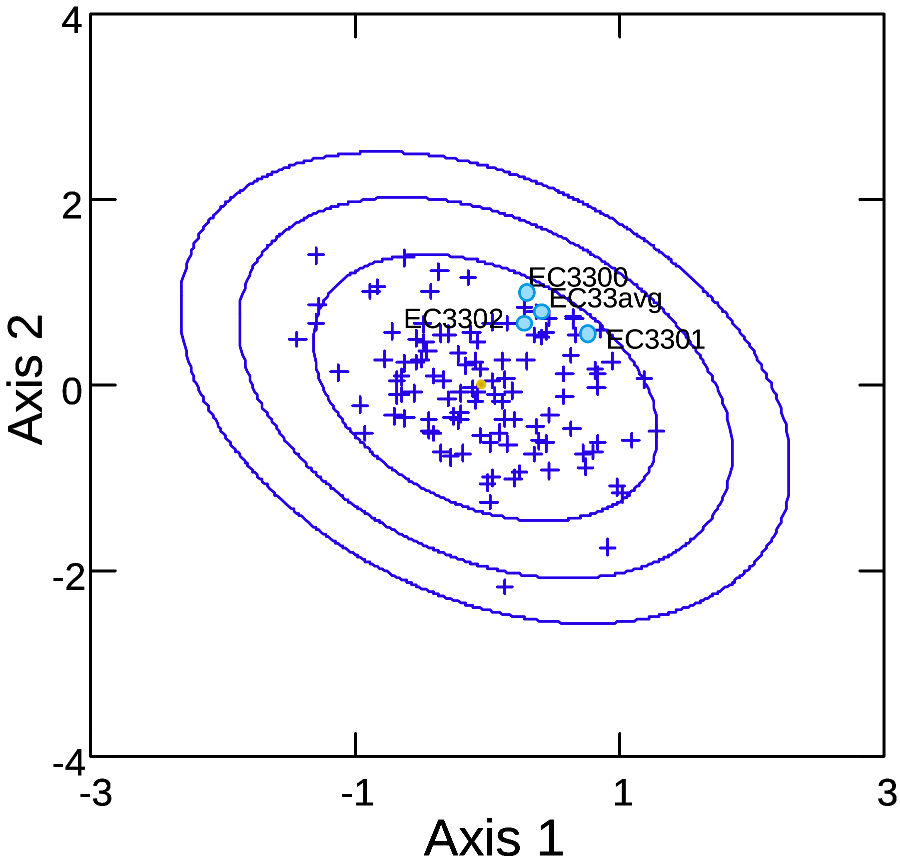


Figure A1. Ordination and assessment of field-replicated QA/QC site EC33 (2009), summarized on Axes 1 and 2. Three separate box cores were taken at the site, indicated by EC3300, EC3301 and EC3302. The mean (EC33avg) of the three box core is also shown. Stress = 0.16.

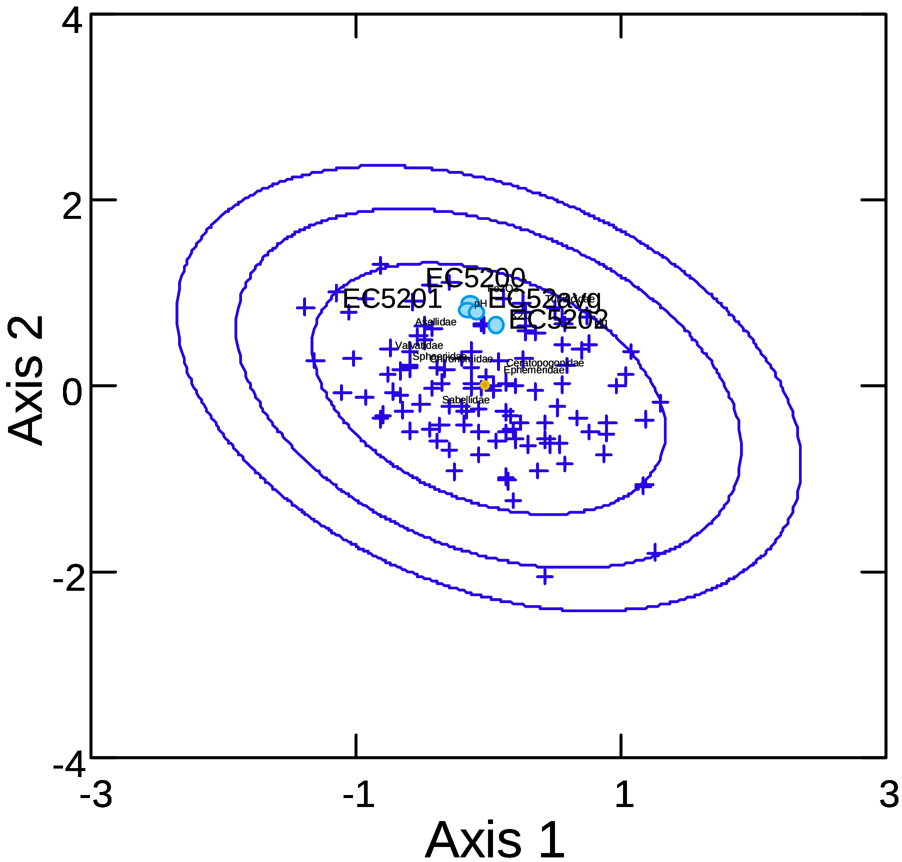


Figure A2. Ordination and assessment of field-replicated QA/QC site EC52 (2010), summarized on Axes 1 and 2. Three separate box cores were taken at the site, indicated by EC5200, EC5201 and EC5202. The mean (EC52avg) of the three box core is also shown. Stress = 0.16.

Appendix B: Benthic Invertebrate Identifications and Counts for 2009-2010

Table B1. Benthic invertebrate identifications and counts (per 33.14 cm^2 – area of core) for East Bellevue Marine Park for 2009-2010.

	Year	2009	2009	2009	2009	2009	2009	2009	2009	2010	2010	2010
	Site	EC30	EC31	EC32	EC33*	EC34	EC35	EC36	EC37	EC52	EC53	EC54
Ephemeroptera	Baetidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Caenidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00
	Ephemeridae	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	8.93	0.60	0.00
	Ephemerellidae	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.20
	Heptageniidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coleoptera	Dytiscidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydrophilidae	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Megaloptera	Sialidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plecoptera	Chloroperlidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diptera-Chironomidae	Chironomidae	18.40	3.00	6.60	14.47	13.80	26.20	39.20	25.60	28.00	34.40	58.60
Diptera	Empididae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Ceratopogonidae	0.00	0.20	0.00	0.07	0.20	0.00	0.60	0.00	3.20	2.80	1.60
	Simuliidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hemiptera	Corixidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trichoptera	Dipseudopsidae	0.00	0.60	0.00	0.13	0.00	0.20	0.60	0.00	0.27	0.40	0.20
	Helicopsychidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydropsychidae	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
	Hydroptilidae	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00
	Leptoceridae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.20
	Molannidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
	Phryganeidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20
	Polycentropodidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.20
	Rhyacophilidae	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
Gastropoda	Ancylidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
	Hydrobiidae	0.00	0.00	0.20	0.07	0.00	0.00	0.00	0.00	1.80	0.20	0.00
	Physidae	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00
	Planorbidae	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	1.20
	Valvatidae	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.40	0.00
	Viviparidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00
Bivalvia	Sphaeriidae	0.20	0.60	0.00	0.07	1.20	0.60	0.40	0.00	0.20	0.00	0.00
Annelida	Enchytraeidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.20	0.00
	Erpobdellidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Glossiphoniidae	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20	0.00	0.00	0.40
	Lumbriculidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Naididae	7.00	30.80	8.80	0.67	8.00	6.40	5.80	0.60	2.00	1.00	3.20
	Sabellidae	0.00	0.00	0.20	0.00	0.00	0.20	5.20	0.00	5.73	0.00	0.20
	Tubificidae	45.20	92.80	81.80	23.27	86.20	75.80	47.00	33.00	21.40	7.80	8.00
Acari	Acari	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Anisitsiellidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Aturidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Feltriidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Halacaridae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hygrobatidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00
	Lebertiidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
	Limnesiidae	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.20	0.00	0.00	0.00
	Mideopsidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Oribatei	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Oxidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pionidae	0.00	0.00	0.20	0.07	0.00	0.00	0.00	0.00	0.13	0.00	0.20
	Torrenticolidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Trhypachthoniidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Unionicolidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crustacea	Asellidae	0.00	0.00	0.00	0.00	0.00	4.40	1.60	1.00	0.33	3.40	8.60
	Amphipoda	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Gammaridae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80
	Hyalellidae sp.	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	2.60
	Pontoporeiidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Crangonyctidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Organisms	Hydridae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Tetrastemmatidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total Abundance	**72**	**128**	**98**	**39**	**110**	**115**	**102**	**61**	**73**	**52**	**87**
	Total No. Taxa	**7**	**6**	**6**	**8**	**7**	**10**	**12**	**6**	**19**	**13**	**17**

[a] QA/QC site (3 box cores taken); average of 15 replicates

Table B2. Benthic invertebrate identifications and counts (per 33.14 cm^2) for Lake George Channel for 2009-2010.

	Year	2009	2009	2009	2009	2010	2010	2010	2010	2010
	Site	**EC38**	**EC39**	**170**	**6901**	**EC47**	**EC48**	**EC49**	**EC50**	**EC51**
Ephemeroptera	Baetidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Caenidae	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
	Ephemeridae	0.00	0.00	6.60	0.00	0.00	0.20	0.00	0.00	0.00
	Ephemerellidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Heptageniidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coleoptera	Dytiscidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydrophilidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Megaloptera	Sialidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plecoptera	Chloroperlidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diptera-Chironomidae	Chironomidae	15.40	4.60	203.60	29.80	24.60	22.00	15.40	31.40	34.20
Diptera	Empididae	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
	Ceratopogonidae	0.20	0.00	10.60	0.00	0.80	0.00	0.00	0.00	1.60
	Simuliidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hemiptera	Corixidae	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trichoptera	Dipseudopsidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
	Helicopsychidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydropsychidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydroptilidae	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.20
	Leptoceridae	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00
	Molannidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Phryganeidae	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
	Polycentropodidae	0.00	0.00	0.40	0.20	0.00	0.00	0.00	0.20	0.00
	Rhyacophilidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gastropoda	Ancylidae	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
	Hydrobiidae	0.00	0.00	2.40	1.00	0.00	0.00	0.40	0.60	0.80
	Physidae	0.00	0.00	0.40	0.20	0.00	0.00	0.00	0.00	0.20
	Planorbidae	0.00	0.20	0.60	1.00	0.00	0.00	4.40	2.00	0.40
	Valvatidae	0.00	0.00	0.20	0.00	0.00	0.20	0.00	0.00	0.40
	Viviparidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bivalvia	Sphaeriidae	0.00	0.00	0.00	0.60	0.00	0.00	0.40	0.00	1.60
Annelida	Enchytraeidae	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00
	Erpobdellidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Glossiphoniidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Lumbriculidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Naididae	9.00	10.60	0.60	2.40	0.40	0.80	1.20	32.00	1.20
	Sabellidae	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
	Tubificidae	112.80	101.20	18.00	37.60	5.40	11.00	42.60	7.00	2.60
Acari	Acari	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Anisitsiellidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Aturidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Feltriidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Halacaridae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hygrobatidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00
	Lebertiidae	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00
	Limnesiidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00
	Mideopsidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Oribatei	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Oxidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pionidae	0.00	0.00	0.00	0.00	0.80	0.00	0.80	0.20	0.40
	Torrenticolidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Trhypachthoniidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Unionicolidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crustacea	Asellidae	0.00	0.00	0.80	3.80	0.00	0.00	16.00	3.40	1.20
	Amphipoda	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Gammaridae	0.20	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00
	Hyalellidae	0.00	0.00	0.00	0.00	0.00	0.00	3.20	0.80	0.20
	Pontoporeiidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Crangonyctidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Organisms	Hydridae	0.00	0.00	0.00	0.00	0.00	0.00	7.00	1.00	0.00
	Tetrastemmatidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total Abundance	**138**	**117**	**247**	**77**	**32**	**34**	**91**	**79**	**45**
	Total No. Taxa	**7**	**5**	**19**	**9**	**6**	**5**	**10**	**12**	**14**

Appendix C: Benthic Invertebrate Community Structure Ordinations for 2009-2010

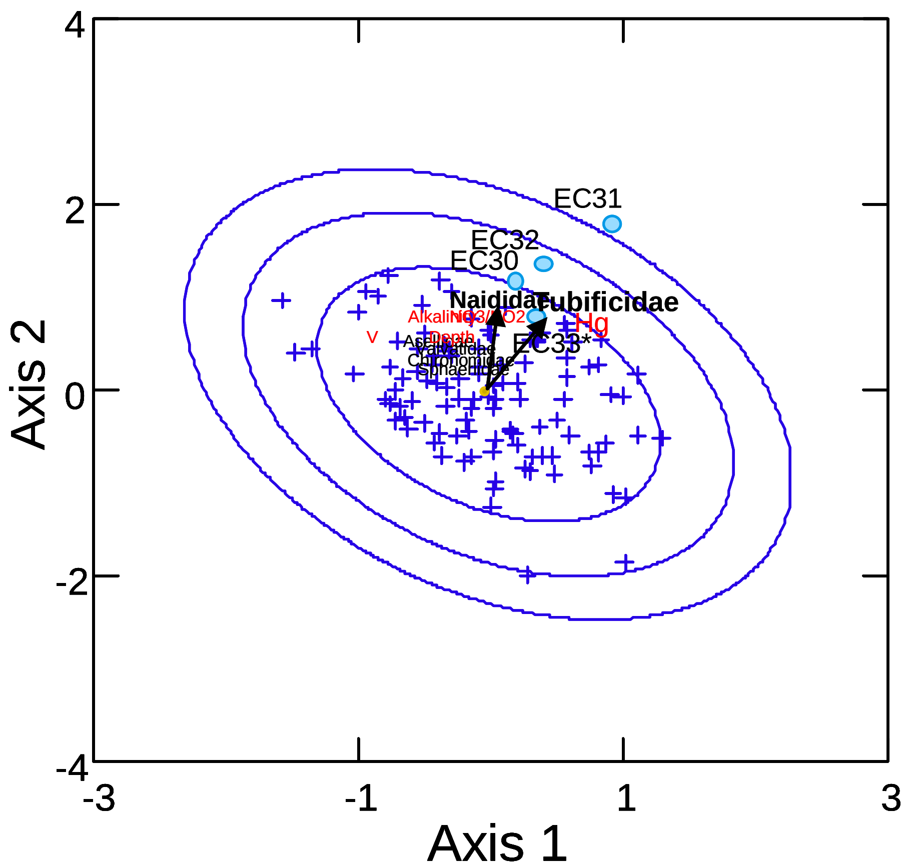


Figure C1. Ordination of subset of 2009 sites in East Bellevue Marine Park (EC30, EC31, EC32, EC33) using family level benthic community data, summarized on 2 of 3 axes, with 90%, 99%, and 99.9% probability ellipses around reference sites (shown as cross hairs) indicated. Invertebrate families that are most correlated to axes scores are shown as vectors. Stress = 0.159.

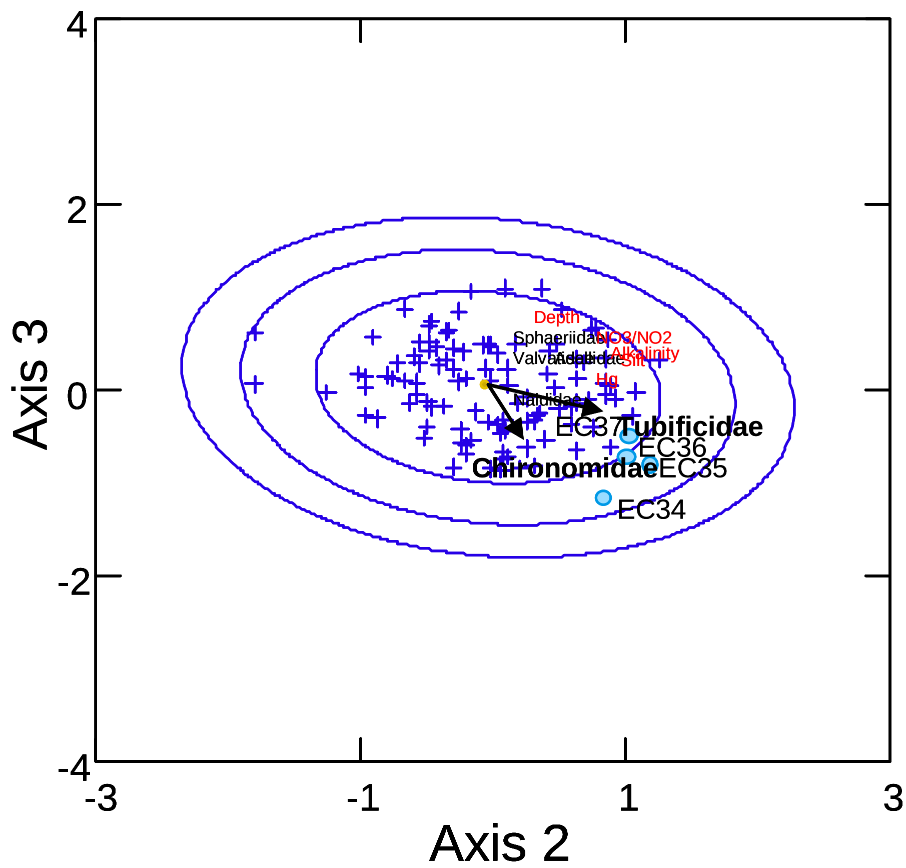


Figure C2. Ordination of subset of 2009 sites in East Bellevue Marine Park (EC34, EC35, EC36, EC37) using family level benthic community data, summarized on 2 of 3 axes, with 90%, 99%, and 99.9% probability ellipses around reference sites (shown as cross hairs) indicated. Invertebrate families that are most correlated to axes scores are shown as vectors. Stress = 0.168.

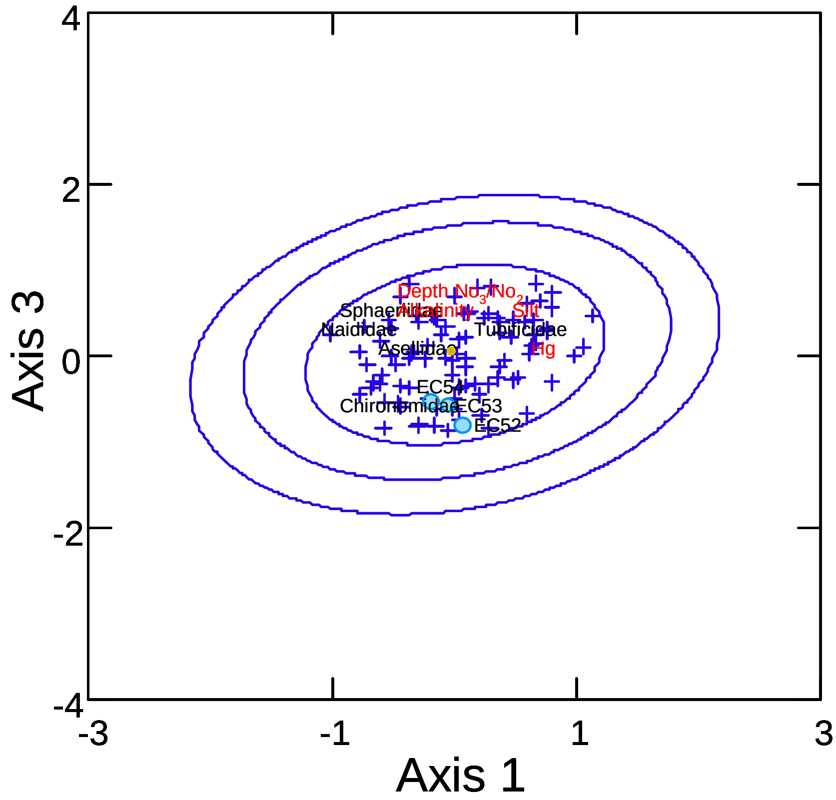


Figure C3. Ordination of subset of 2010 sites in East Bellevue Park (EC52, EC53, EC54) using family level benthic community data, summarized on 2 of 3 axes, with 90%, 99%, and 99.9% probability ellipses around reference sites (reference scores shown as cross hairs) indicated. Invertebrate families that are most correlated to axes scores are shown as vectors. Stress = 0.155.

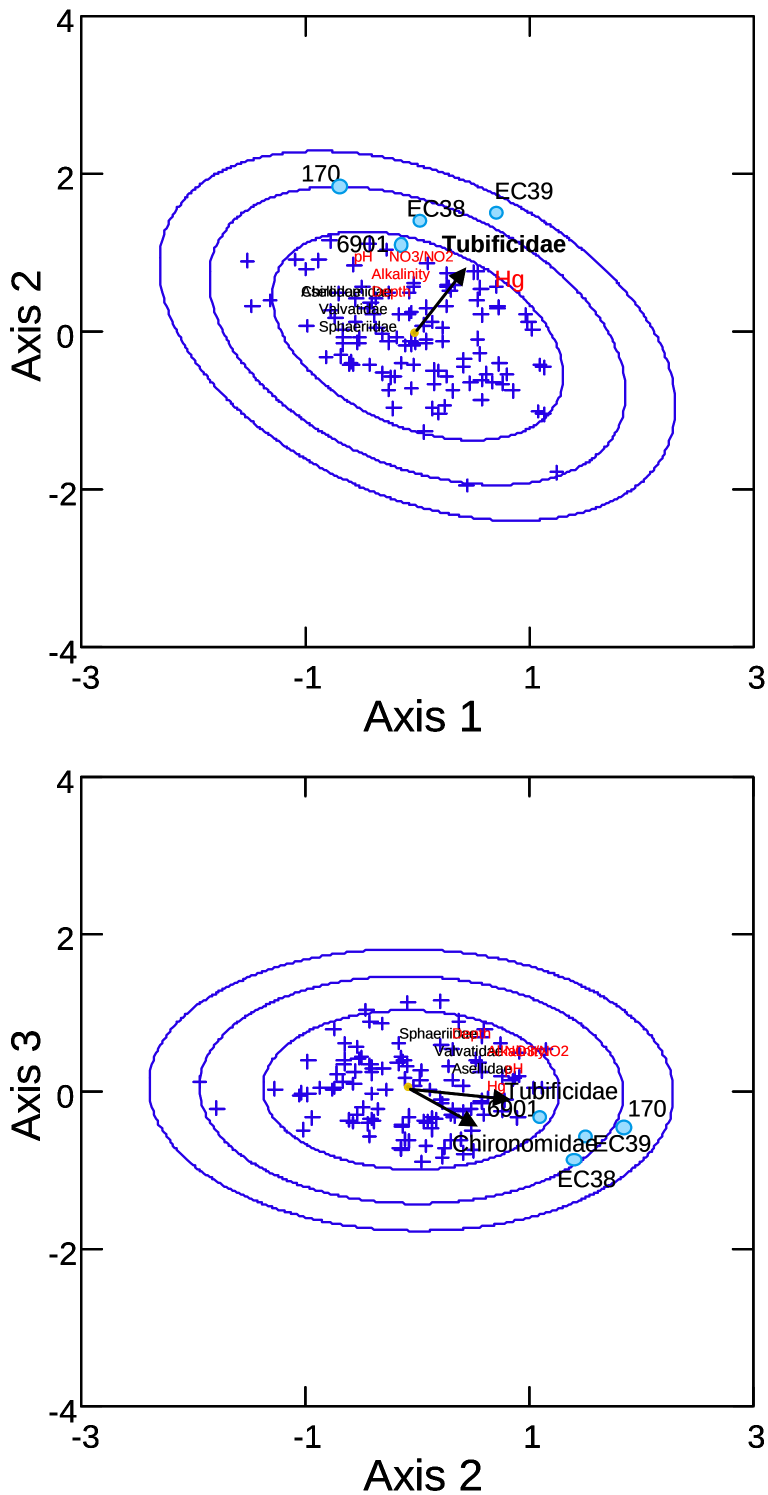


Figure C4. Ordination of 2009 sites in Lake George Channel (170, EC38, EC39, 6901) using family level benthic community data, summarized on Axes 1 & 2 (top) and Axes 2 & 3 (bottom), with 90%, 99%, and 99.9% probability ellipses around reference sites (shown as cross hairs) indicated. Invertebrate families that are most correlated to axes scores are shown as vectors. Stress = 0.158.

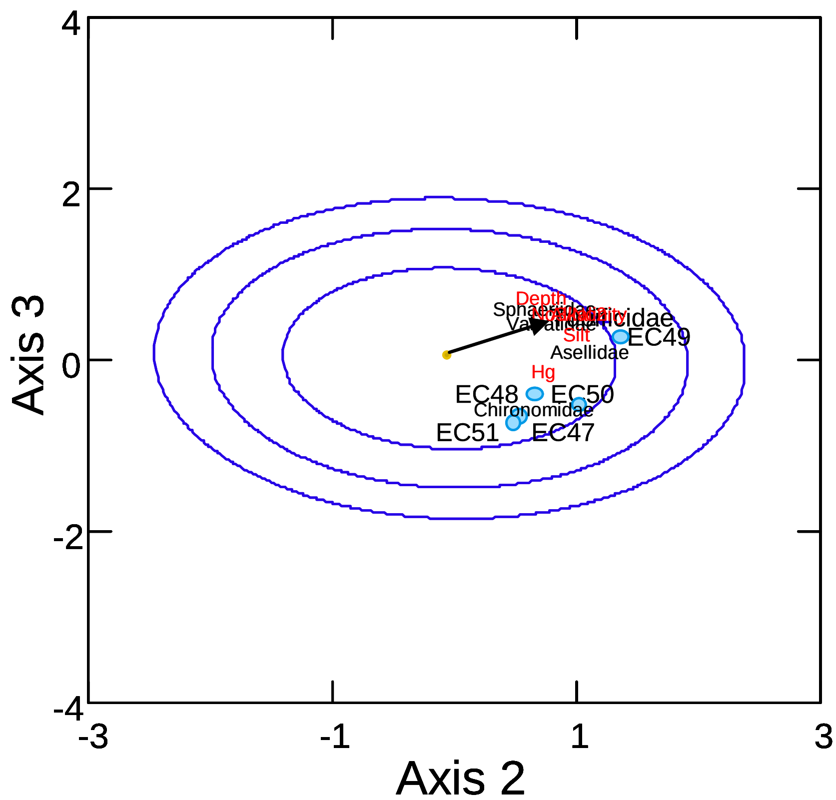


Figure C5. Ordination of subset of 2010 sites in Lake George Channel (EC47 to EC51) using family level benthic community data, summarized on 2 of 3 axes, with 90%, 99%, and 99.9% probability ellipses around reference sites (reference site scores not shown). Invertebrate families that are most correlated to axes scores are shown as vectors. Stress = 0.160.

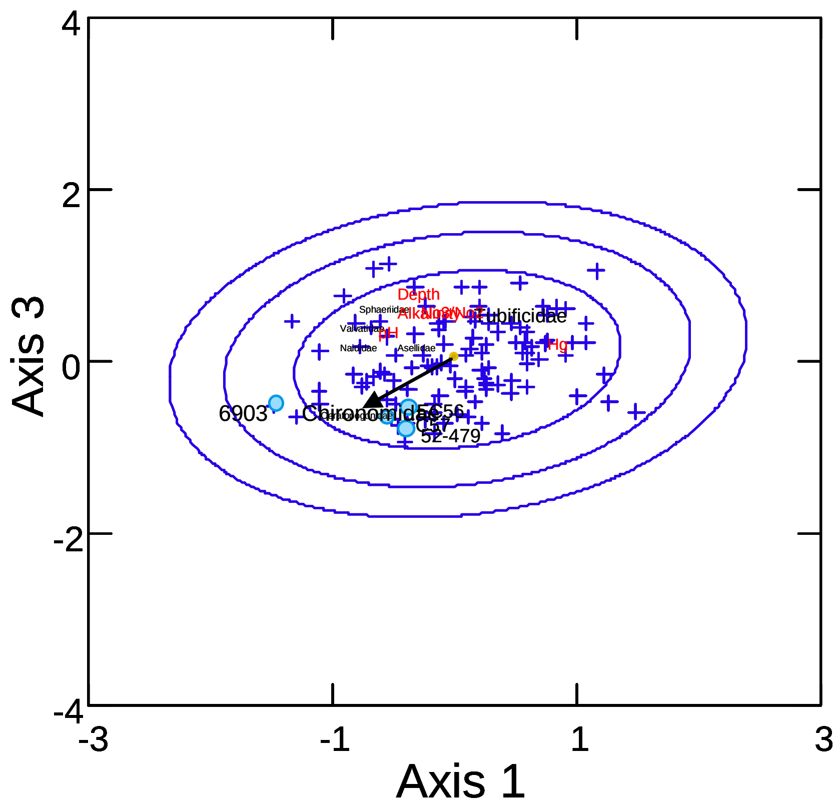


Figure C6. Ordination of subset of 2010 Upstream Reference sites (6903, EC56, EC57, 52-479) using family level benthic community data, summarized on 2 of 3 axes, with 90%, 99%, and 99.9% probability ellipses around reference sites (shown as cross hairs) indicated. Invertebrate families that are most correlated to axes scores are shown as vectors. Stress = 0.157.

Appendix D: Toxicity Ordinations for 2009-2010

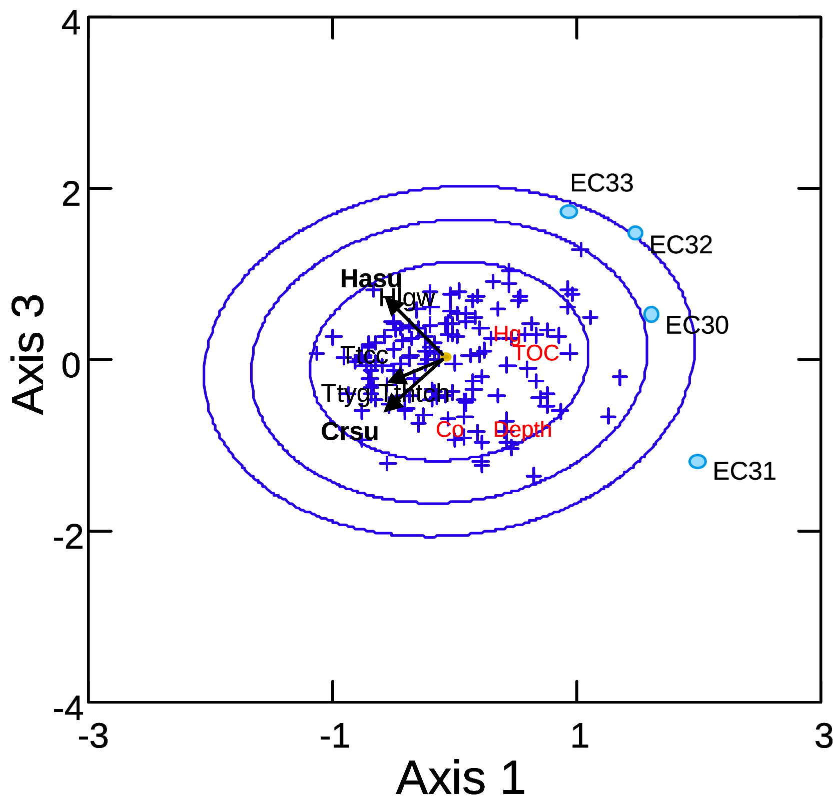


Figure D1. Ordination of subset of 2009 sites in East Bellevue Marine Park using 10 toxicity test endpoints, summarized on Axes 1 and 3, with 90%, 99%, and 99.9% probability ellipses around reference sites (reference site scores shown as cross hairs). Hasu = *Hyalella azteca* survival; Ttcc, Tthtch and Ttyg = *Tubifex tubifex* cocoon production, percent cocoons hatched and young production; Crsu = *Chironomus riparius* survival; Hlgw = *Hexagenia* spp. growth. Remaining endpoints were not significant (p< 0.01). Stress = 0.108. Note: Site EC33 is in Band 4, outside the 99.9% ellipse, on Axis 2 (not shown).

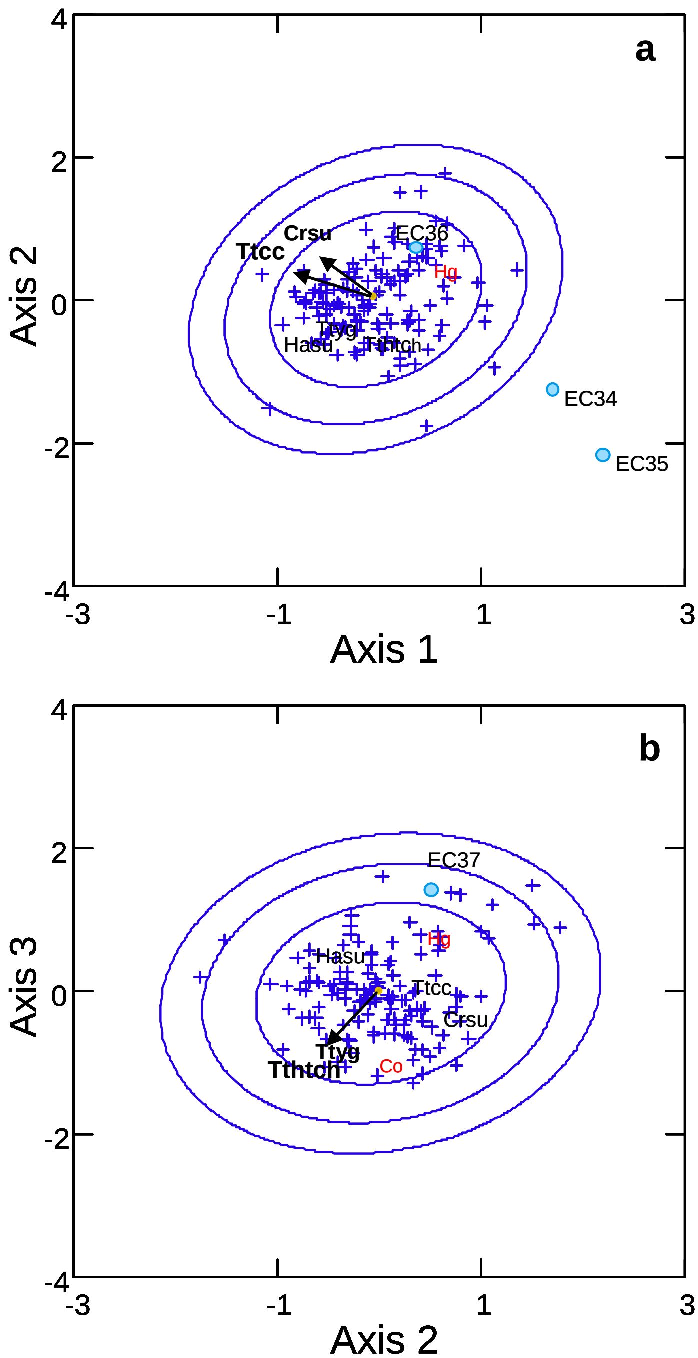


Figure D2. Ordination of subset of 2009 sites in East Bellevue Marine Park using 10 toxicity test endpoints, summarized on Axes 1 and 3 (a) and Axes 2 and 3 (b) with 90%, 99%, and 99.9% probability ellipses around reference sites (reference site scores shown as cross hairs). Crsu = *Chironomus riparius* survival; Hasu = *Hyalella azteca* survival; Ttcc, Ttyg, Tthtch= = *Tubifex tubifex* cocoon production, percent cocoons hatched, young production. Remaining endpoints were not significant ($p< 0.05$). Stress = 0.11.

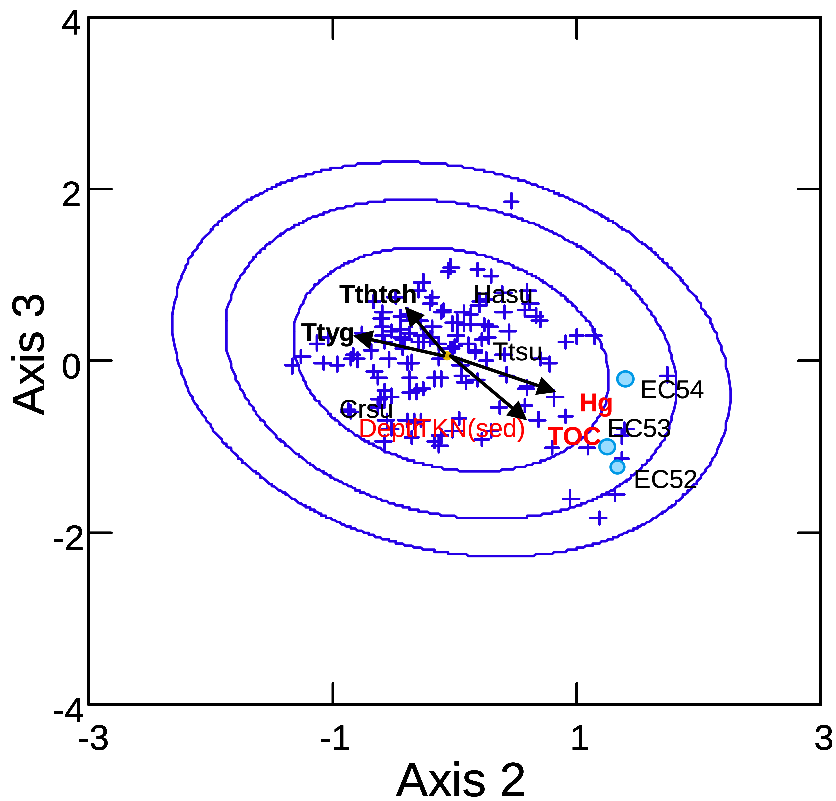


Figure D3. Ordination of 2010 sites in East Bellevue Marine Park using 10 toxicity test endpoints, summarized on Axes 2 and 3, with 90%, 99%, and 99.9% probability ellipses around reference sites (reference site scores shown as cross hairs). Hasu = *Hyalella azteca* survival; Crsu = *Chironomus riparius* survival; Ttsu, Tthtch, Ttyg = *Tubifex tubifex* survival, percent cocoons hatched, young production. Remaining endpoints were not significant ($p < 0.01$). Stress = 0.115.

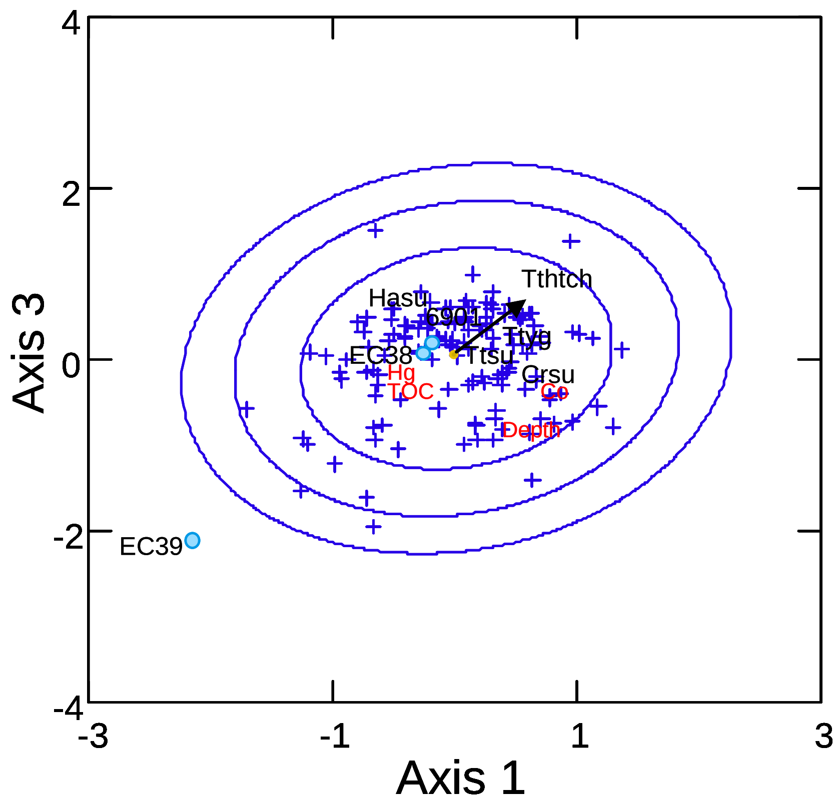


Figure D4. Ordination of 2009 sites in Lake George Channel using 10 toxicity test endpoints, summarized on Axes 2 and 3, with 90%, 99%, and 99.9% probability ellipses around reference sites (reference site scores shown as cross hairs). Hasu = *Hyalella azteca* survival; Crsu = *Chironomus riparius* survival; Ttsu, Tthtch, Ttyg = *Tubifex tubifex* survival, percent cocoons hatched, young production. Remaining endpoints were not significant ($p < 0.01$). Stress = 0.114.

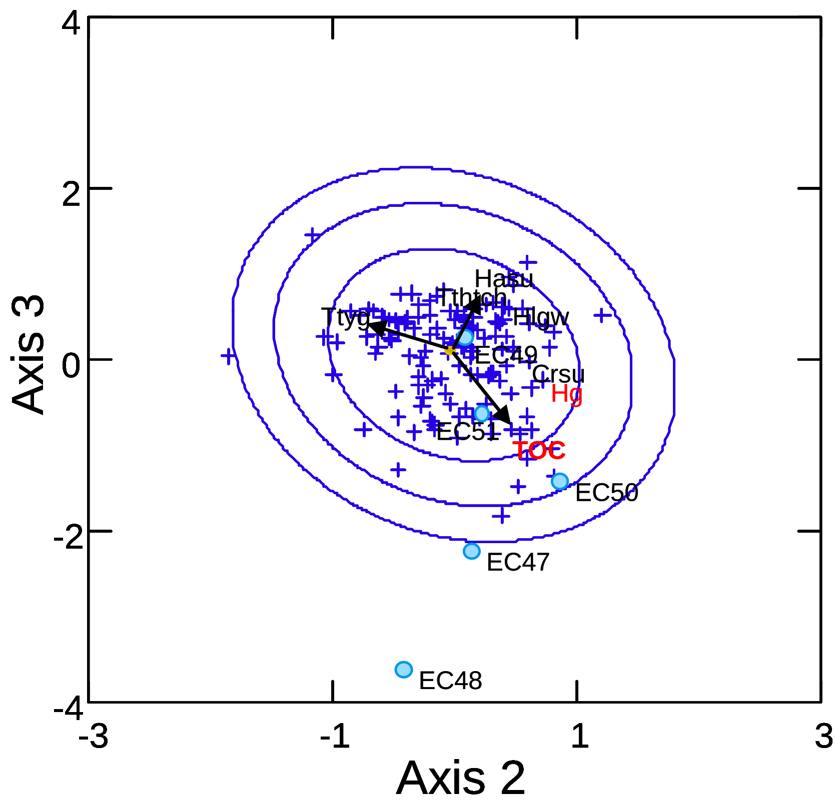


Figure D5. Ordination of 2010 sites in Lake George Channel using 10 toxicity test endpoints, summarized on Axes 2 and 3, with 90%, 99%, and 99.9% probability ellipses around reference sites (reference site scores shown as cross hairs). Hasu = *Hyalella azteca* survival; Crsu = *Chironomus riparius* survival; Tthtch, Ttyg = *Tubifex tubifex* percent cocoons hatched, young production and; Hlgw = *Hexagenia* spp. growth. Remaining endpoints were not significant ($p < 0.01$). Stress = 0.110.

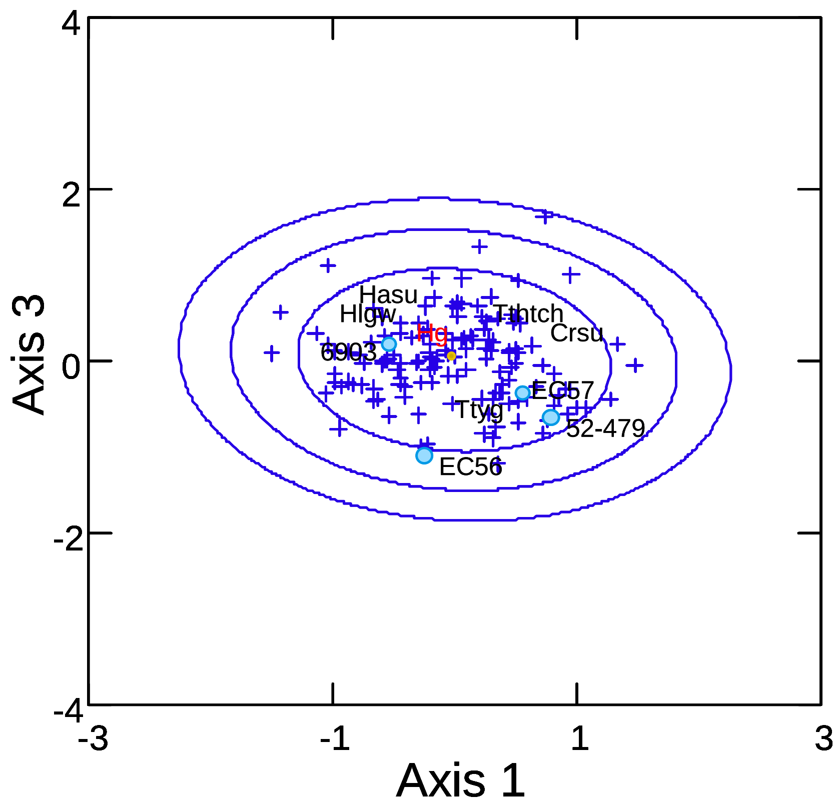


Figure D6. Ordination of 2010 Upstream Reference sites using 10 toxicity test endpoints, summarized on Axes 2 and 3, with 90%, 99%, and 99.9% probability ellipses around reference sites (reference site scores shown as cross hairs). Hasu = *Hyalella azteca* survival; Crsu = *Chironomus riparius* survival; Ttcc, Tthtch, Ttyg = *Tubifex tubifex* cocoon production, percent cocoons hatched, young production; Hlgw = *Hexagenia* spp. growth. Remaining endpoints were not significant ($p < 0.01$). Stress = 0.118.

Appendix E: Toxicity-Contaminant Relationships for 2009-2010

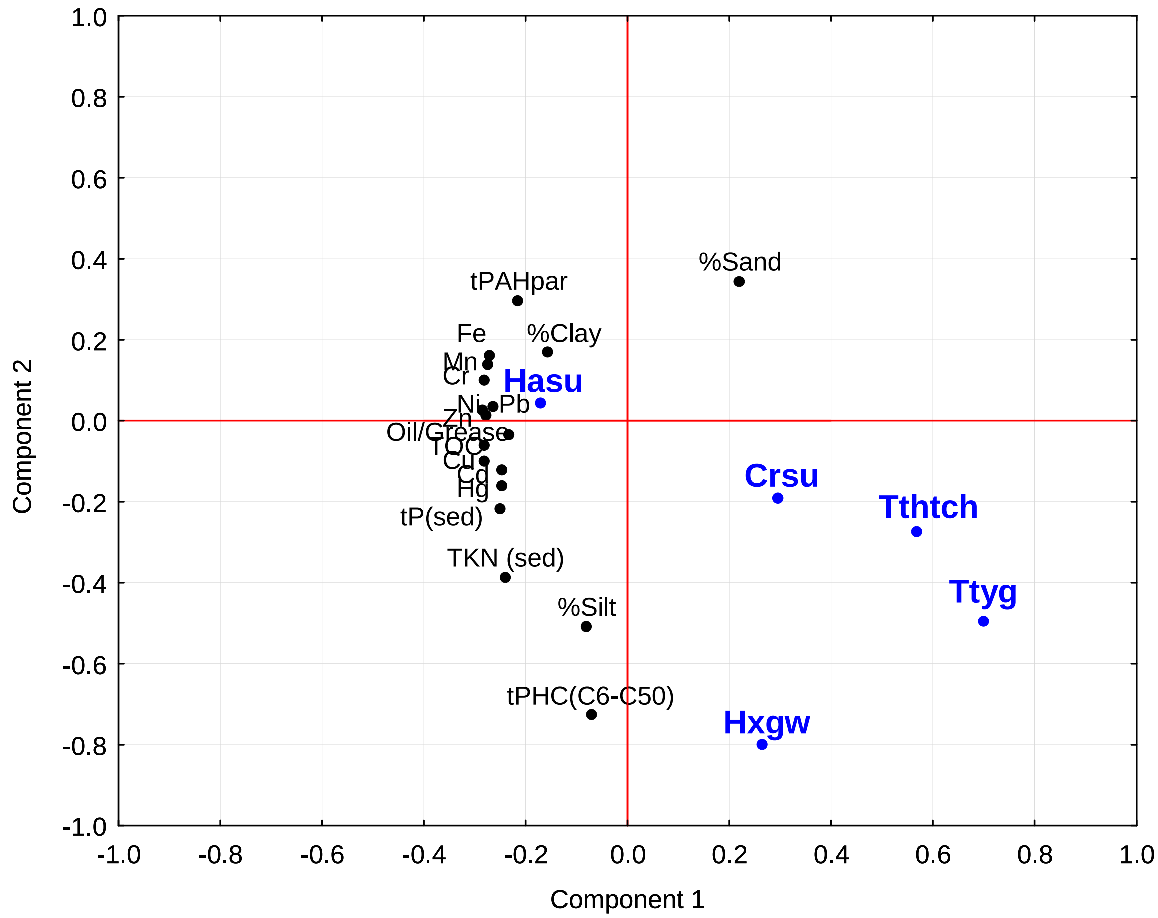


Figure E1. Loadings (metals, nutrients, particle sizes & integrated organic contaminant variables) and scores (toxicity endpoints) of partial least squares analysis of toxicological response of benthic invertebrates exposed to St. Marys River sediment, 2009 and 2010 data. Hasu = *Hyalella azteca* survival; Crsu = *Chironomus riparius* survival; Tthtch, Ttyg = *Tubifex tubifex* percent cocoons hatched, young production; Hxgw = *Hexagenia* spp. growth.

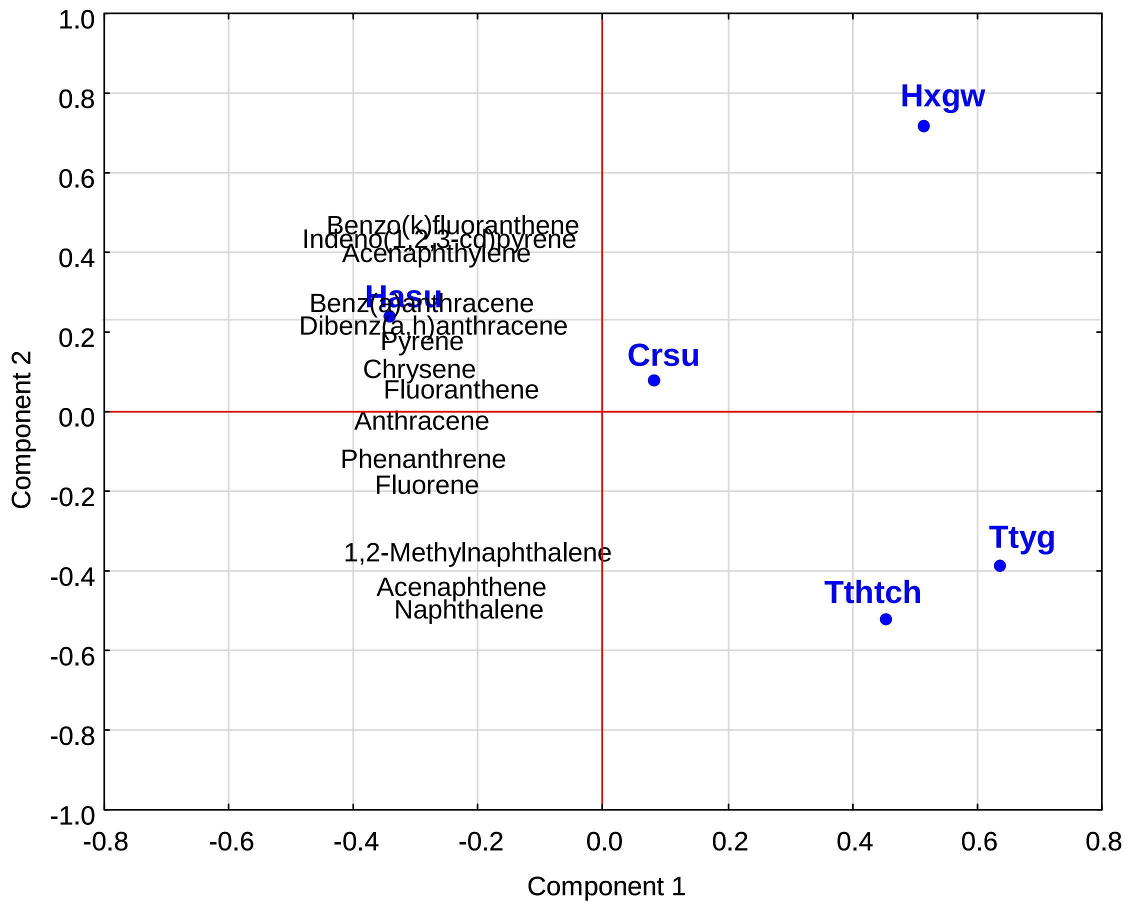


Figure E2. Loadings (parent PAH compounds) and scores (toxicity endpoints) of partial least squares analysis of toxicological response of benthic invertebrates exposed to St. Marys River sediment, 2009 and 2010 data. Hasu = *Hyalella azteca* survival; Crsu = *Chironomus riparius* survival; Tthtch, Ttyg = *Tubifex tubifex* percent cocoons hatched, young production; Hxgw = *Hexagenia* spp. growth.

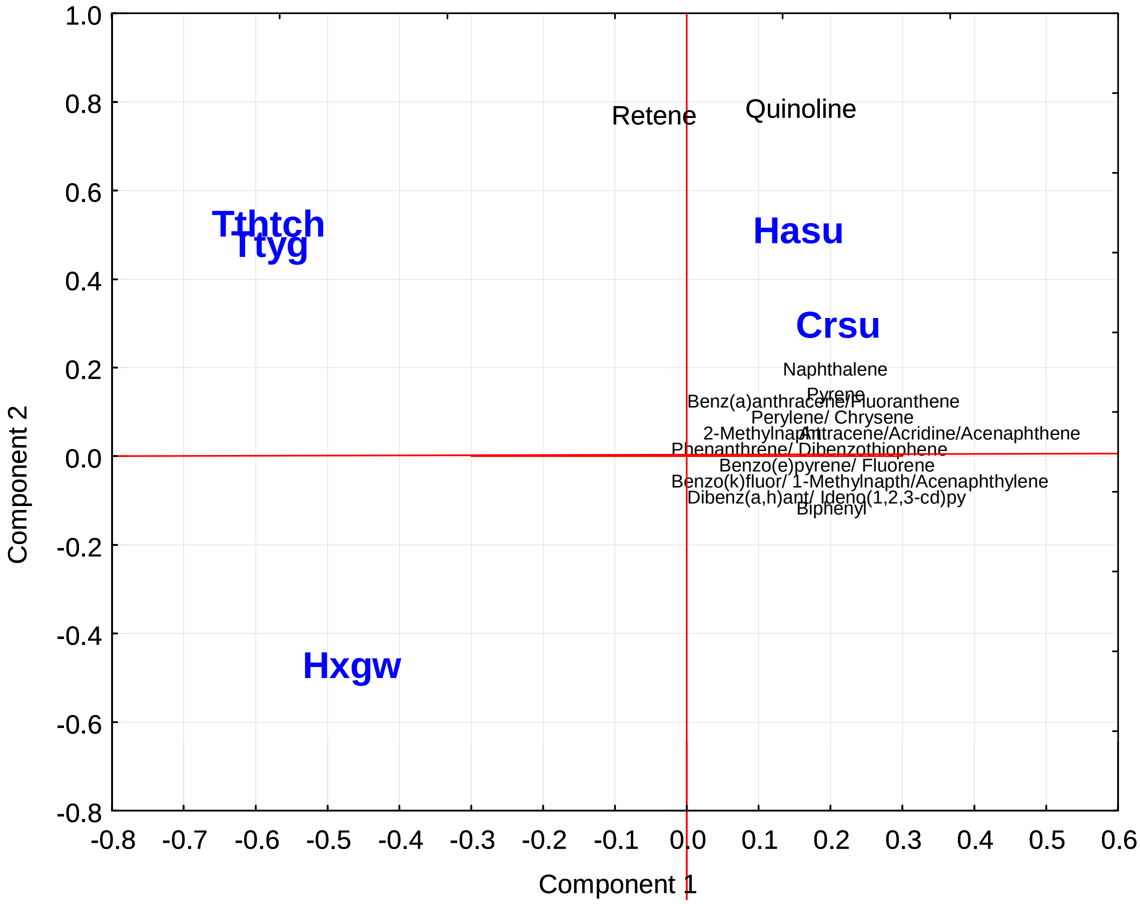


Figure E3. Loadings (parent PAH compounds) and scores (toxicity endpoints) of partial least squares analysis of toxicological response of benthic invertebrates exposed to St. Marys River sediment, 2010 data. Hasu = *Hyalella azteca* survival; Crsu = *Chironomus riparius* survival; Tthtch, Ttyg = *Tubifex tubifex* percent cocoons hatched, young production; Hxgw = *Hexagenia* spp. growth.

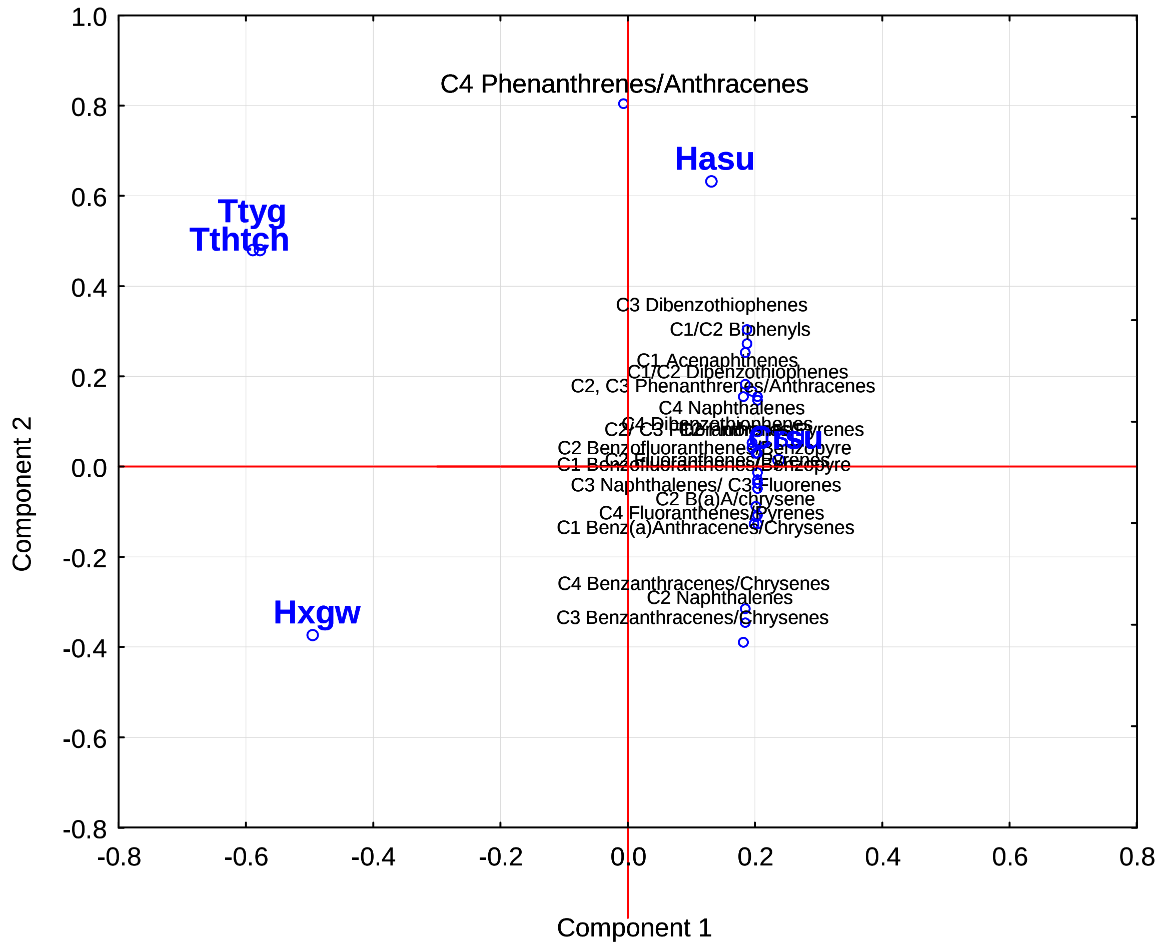


Figure E4. Loadings (alkylated PAH compounds) and scores (toxicity endpoints) of partial least squares analysis of toxicological response of benthic invertebrates exposed to St. Marys River sediment, 2010 data. Hasu = *Hyalella azteca* survival; Crsu = *Chironomus riparius* survival; Tthtch, Ttyg = *Tubifex tubifex* percent cocoons hatched, young production; Hxgw = *Hexagenia* spp. growth.

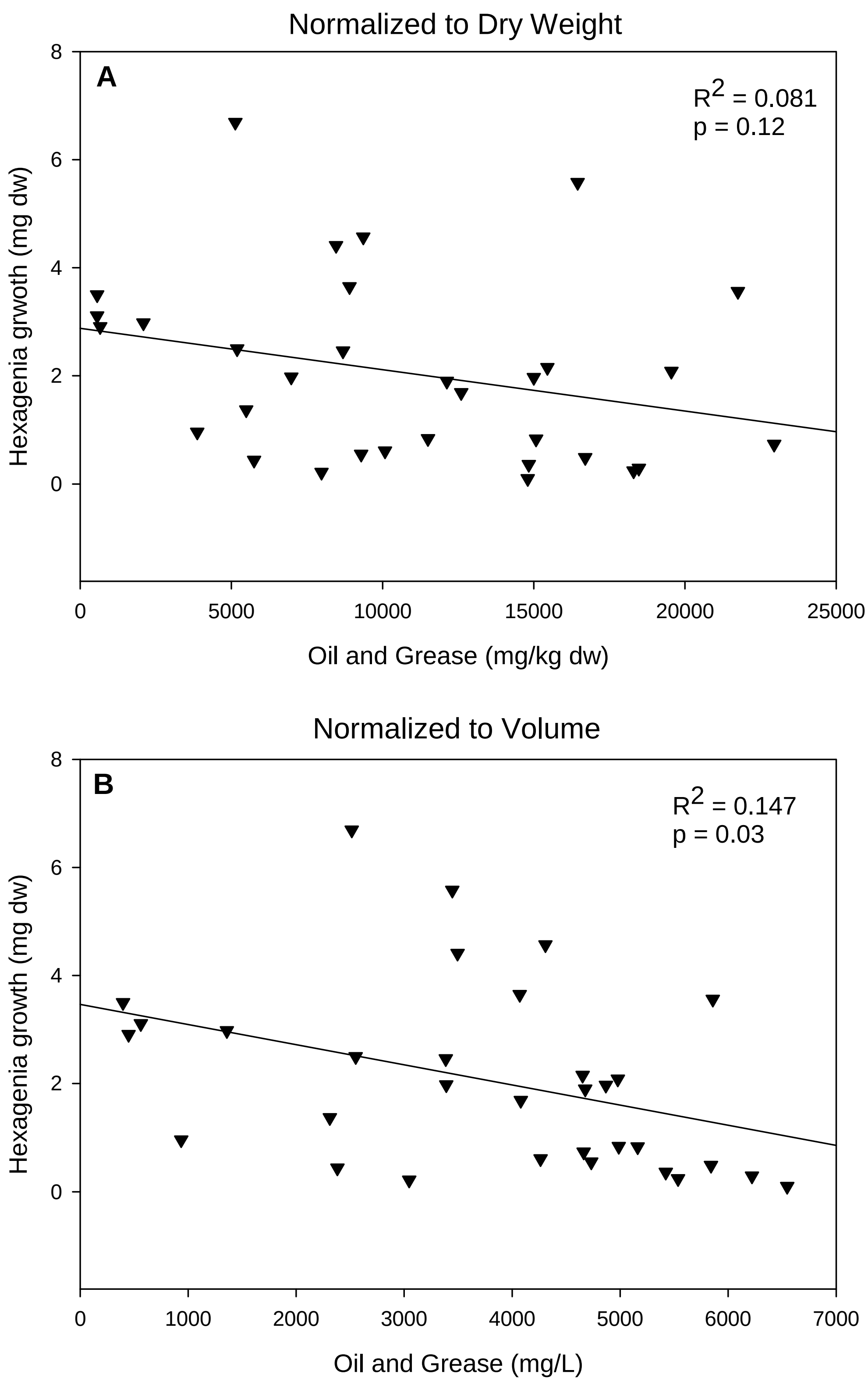
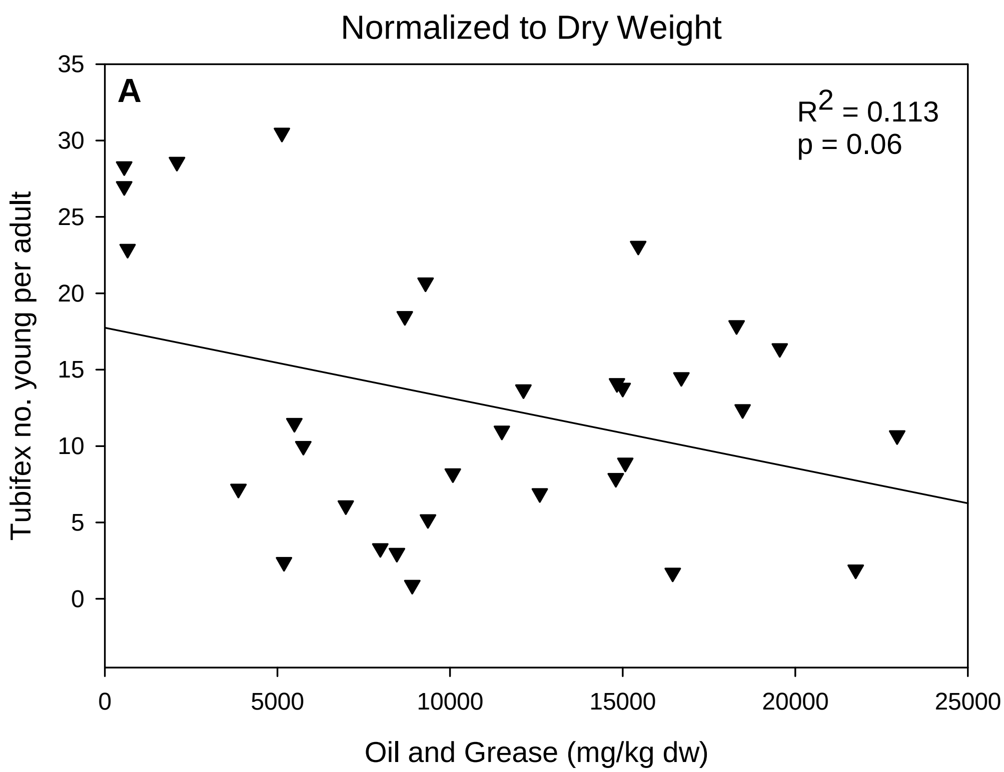


Figure E5. Relationship between *Hexagenia* growth and oil and grease, A) normalized to dry weight and B) normalized to volume.



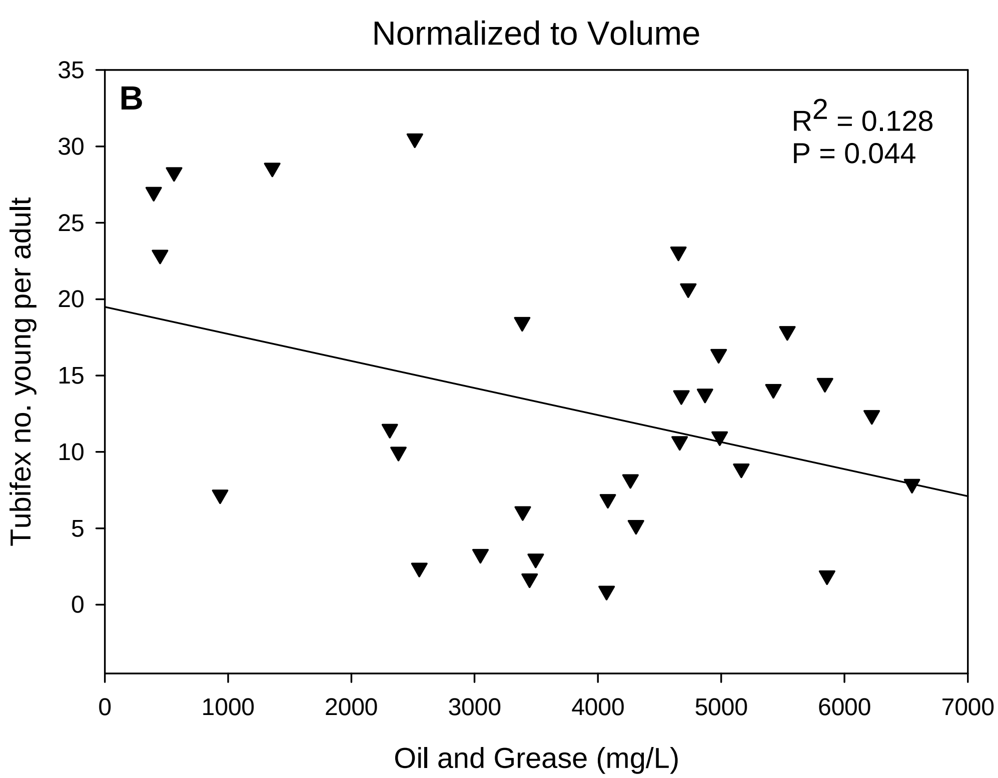


Figure E6. Relationship between *Tubifex* young production and oil and grease, A) normalized to dry weight and B) normalized to volume.

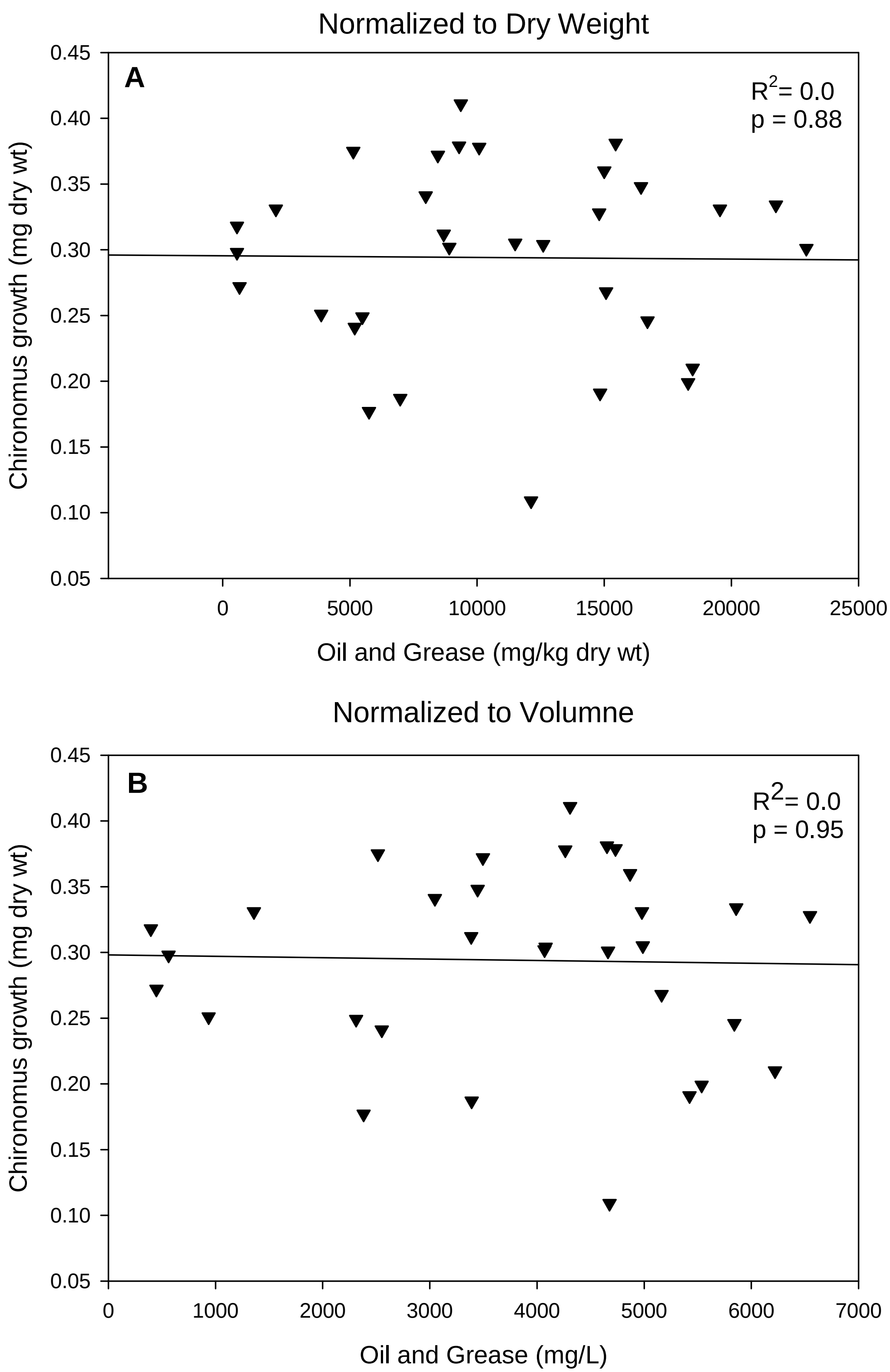


Figure E7. Relationship between Chironomus growth and oil and grease, A) normalized to dry weight and B) normalized to volume.

Environment Canada | Environnement Canada

Canada Centre for Inland Waters
P.O. Box 5050
867 Lakeshore Road
Burlington, Ontario
L7R 4A6 Canada

Centre canadien des eaux intérieures
Case postale 5050
867, chemin Lakeshore
Burlington (Ontario)
L7R 4A6 Canada

National Hydrology Research Centre
11 Innovation Boulevard
Saskatoon, Saskatchewan
S7N 3H5 Canada

Centre national de recherche en hydrologie
11, boul. Innovation
Saskatoon (Saskatchewan)
S7N 3H5 Canada

St. Lawrence Centre
105 McGill Street
Montreal, Quebec
H2Y 2E7 Canada

Centre Saint-Laurent
105, rue McGill
Montréal (Québec)
H2Y 2E7 Canada

Place Vincent Massey
351 St. Joseph Boulevard
Gatineau, Quebec
K1A 0H3 Canada

Place Vincent-Massey
351 boul. St-Joseph
Gatineau (Québec)
K1A 0H3 Canada

Canada