Toronto & Region Remedial Action Plan

BUI Status Re-designation Document:

Restrictions on Dredging Activities

January 30, 2014 Draft

For additional copies of this report please contact:

Toronto and Region Conservation Authority
5 Shoreham Drive
Toronto, ON
M3N 1S4
www.trca.on.ca
phone: (416) 661-6600 ext. 5576
fax: (416) 661-6898

The Toronto and Region Remedial Action Plan is managed by representatives from Environment Canada (EC), Ontario Ministry of the Environment (MOE), Ontario Ministry of Natural Resources and Toronto and Region Conservation Authority.

Introduction

In 1985, based on recommendations from U.S. and Canadian federal governments, the Great Lakes states and the Province of Ontario, the International Joint Commission (IJC) identified 42 (later 43) areas in the Great Lakes where contaminant concerns existed. These "Areas of Concern" (AOCs) formed the priority sites for environmental actions. The original listing of AOCs was based on a list of 14 designated beneficial use impairments (BUIs). The BUIs noted the major environmental impairments in each of the AOCs, and identified the issues that would need to be addressed for the area to be delisted as an AOC. In many of these areas, contaminated sediments were identified as one of the causes of the use impairments and a number of the BUIs related directly to contaminated sediment issues:

- Degradation of benthos;
- Restrictions on fish and wildlife consumption;
- Fish tumours or other deformities;
- Bird or animal deformities or reproduction problems; and
- Restrictions on dredging activities.

This report summarizes the rationale for re-designating the “restrictions on dredging” beneficial use within the Toronto and Region Area of Concern from impaired to not impaired. Routine dredging to maintain adequate depth in navigational channels and harbours occurs in many locations throughout the Great Lakes. Chemical specific guidelines have historically been used in both the U.S. and Canadian portions of the Great Lakes to assess the suitability of disposing of the dredged material in open lake environments. In cases where chemical contaminants exceed the open water disposal guidelines the dredged material is not considered suitable for disposal in the open lake and must be disposed or managed in a more expensive manner within an engineered confined disposal facility or in an appropriate landfill or upland disposal site. Generally, open water disposal of dredged material is less expensive than other alternatives for management of this material.

In its 1991 guidance for listing and de-listing beneficial uses, the International Joint Commission considers “restrictions on dredging” impaired “When contaminants in sediments exceed standards, criteria, or guidelines such that there are restrictions on dredging or disposal activities.”

In the report, Metro Toronto Remedial Action Plan: Environmental Conditions and Problem Definition, 1989, restrictions on dredging was assessed against the Provincial Open Water Disposal Guidelines developed in 1976 (Persaud and Wilkins 1976) and considered impaired. This initial assessment concluded, “Sediments in most embayment areas exceed Ontario’s open water disposal guidelines and dredging has been subject to Environmental Assessment in the past and is likely to be in the future”. In the repot Metro Toronto & Region Remedial Action Plan: Clean Waters, Clear Choices, 1994 the goals or de-listing criteria for restrictions on dredging is stated as “Dredged sediments meet Provincial Sediment Quality Guidelines”.

This broad based application of “restrictions on dredging” to locations within an AOC that are not dredged is contrary to the intent of this beneficial use which is appropriately applied to locations that require maintenance dredging to maintain shipping channels or for other purposes (Montgomery and Krantzberg, 2007and Federal and Provincial Review of Restrictions on Dredging, un-published 1998).

Over the years, field studies and research on contaminated sediment has advanced our knowledge and understanding to more accurately assess environmental risk posed by sediment-bound chemicals. This experience and knowledge has shown that Provincial Sediment Quality Guidelines by themselves are poor predictors of environmental effects. As a result, in 1996 the MOE published a guidance document (Jaagumagi and Persuad et al 1996) to assist environmental managers better evaluate the environmental risk posed by contaminated sediment. This newer approach advanced beyond the application of sediment chemistry and comparisons to sediment guidelines to include biological effects based assessments where guidelines were exceeded. The addition of effects based testing provides stronger evidence upon which to base conclusions on whether sediment-bound contaminants pose an environmental risk. Building on the MOE 1996 approach and further experience evaluating and managing contaminated sediment in several Great Lakes AOCs (e.g. St. Clair River, St. Lawrence River (Cornwall), Thunder Bay), Environment Canada and the MOE published the Canada-Ontario Decision-Making Framework for Assessment of Great Lakes Contaminated Sediments in 2007 (COA Framework).

The COA Framework uses an ecosystem weight of evidence approach to better assess environmental risk posed by contaminated sediment. It considers potential effects on sediment-dwelling and aquatic organisms, as well as potential for contaminants to accumulate in the food chain. Under this more advanced approach to assessing contaminated sediment, the PSQGs are again used as a precautionary screen to identify whether further biological tests and ecological and human health risk assessments are warranted. The COA Decision-Making Framework was developed as a standardized approach to examine contaminated sediment throughout the Great Lakes region regardless of whether it is located within or outside an Area of Concern.

Open water disposal of sediment was considered an economically beneficial use, and it has always been recognized that this was not a benign activity and that there were environmental impacts associated with open water disposal. Disposing of dredged sediment in open water environments may smother the benthic organisms living in and on the sediment or change the habitat conditions. Due to these concerns, a number of states (Wisconsin, Michigan, Ohio) have severely restricted open water disposal on environmental grounds (http://www.glc.org/dredging/case/documents/OpenWaterFinal.pdf). Ontario permits open water disposal, provided that the conditions regarding adequacy of sediment characteristics to disposal location (MOE 2008) are met, but encourages proponents to find other beneficial uses for the material (the MOE typically requires additional environmental studies to demonstrate that open water disposal will not adversely affect the aquatic environment even where sediment concentrations of contaminants may not be a concern).

Dredging Activity in the Toronto and Region AOC

Within the Toronto and Region AOC, dredging activities are limited, and currently the only regular dredging activity is undertaken in the Keating Channel to remove the build up of material deposited by the Don River in order to maintain depth and reduce the flood potential in the lower section of the river. Disposal of this dredged material is governed by the 1982 Keating Channel Environmental Assessment which requires placement of the dredged sediment in one of three confined disposal sites (CDFs) constructed in 1979 as part of a major expansion of land area for what is now called Tommy Thompson Park (Figure 1).

Dredging is also occasionally undertaken around Ashbridges Bay and in the Eastern and Western Gaps (see Figure 1 for locations) to remove material that has drifted around the entrance of the bay or into the channels. This material is mostly clean sand and is re-used for beach nourishment in areas along the waterfront where active shoreline erosion occurs or for habitat restoration projects. As a result, open-water disposal of sediments is not currently undertaken in the Toronto and Region AOC.

Keating Channel Sediment

The Toronto and Region Conservation Authority has been monitoring the Keating Channel sediment as part of the dredging activities since 1987. Tables 1a and 1b provide a summary annual mean Keating Channel sediment contaminant concentrations and Figure 3 depicts the contaminant trends over this period. These data show improvement in sediment quality and mean concentrations of a number of metals (cadmium, lead, mercury and zinc) over the 24 year period. During this same period of monitoring copper and nutrient concentrations have been unchanged and Total Organic Carbon (TOC) has an increasing trend but this is most likely due to a shift to fall sampling in more recent years which has resulted in a higher content of leaf (pers. comm. Potriss, R., October 2013). PCBs concentrations were below the detection levels of 0.3 ug/kg, in 2009, 2010 and 2011. In 2012 elevated levels of PCBs were encountered with concentrations ranging as high as 0.5 mg/kg and mean value of 0.17 mg/kg. The 2012 PCB mean concentration exceeds Ontario's Lowest Effect Level (LEL) of 0.07 mg/kg but the both the mean and maximum concentrations are well below the Severe Effect Level (SEL) of 530 mg/kg. Total phosphorus, TKN, TOC, cadmium, copper and lead concentrations were also above the LEL however, all parameter concentrations were well below PSQG Severe Effect Level.

Comparison of Keating Channel means to means for the Lake Ontario Mississauga Basin (Marvin 2003) and Environment Canada's Near Shore Site 1002 (see Figure 2) shows that Keating Channel sediment quality is better than either of these two non-AOC locations. Mississauga Basin contaminant mean concentrations ranged between 1.3 and 10 times higher and Site 1002 concentrations ranged from 1 to 3.7 times higher than in Keating Channel sediment. The exceptions being PCBs which were 2.2 times higher in Keating Channel sediment (see Table 2) than the Lake Ontario wide average reported by Marvin, et al., 2003.

Table 1a: Summary of Keating Channel Sediment Mean Annual 1987-1999 Contaminant Concentrations (mg/kg)

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Arsenic		1.86	4.22	4.89	2.57	3.20	1.09	2.21	2.68	2.31	3.23	2.68	1.90
Cadmium	1.68	1.56	2.15	1.32	1.29	1.43	0.70	1.06	1.06	1.01	0.52	0.78	0.58
Chlordane													
Chromium													
Copper					54	49	22	54	60	47	43	98	43
Iron %					1.98	1.32	0.99	1.27	2.40	1.34	1.34	1.74	1.70
Mercury	0.29	0.20	0.27	0.20	0.17	0.24	0.04	0.17	0.28	0.16	0.12	0.51	0.10
LOI	6.64	8.16	5.79	5.05	3.91	4.94	3.81	6.80	7.43	9.50	4.97	5.63	4.30
Manganese					417	390	237	441	484	346	399	1087	408
Nickel													
Oils & Grease	4030	4417	1836	1907	4627	2802	2643	3210	6658	2030	2220	1622	1362
Lead	224	177	157	110	99	74	38	66	65	77	44	53	35
PCBs													
pp'-DDT													
pp'-DDD													
pp'DDE													
TKN	1359	1266	1560	1516	1475	1965	391	933	2177	1260	1558	1750	952
TOC %	1.90	1.63	2.07	1.92	2.56	2.50	1.00	2.74	3.02	2.00	2.09	3.38	2.64
Total Phosphorus	1141	1051	848	741	939	982	590	963	1060	804	874	1151	1080
Zinc	259	223	222	177	191	175	90	202	149	164	164	187	155
Total PAHs							<2.16		<3.09	<4.81	<2.36		

Green shading indicates values below the Lowest Effect Level

Yellow shading indicates values above the Lowest Effect Level and below the Severe Effect Level

Red shading indicates values above the Severe Effect Level

Mauve shading indicates reported detection limits above the Lowest Effect Level

Table 1b: Summary of Keating Channel Sediment Mean Annual 1987-2012 Contaminant Concentrations (mg/kg)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Arsenic	1.13	0.45	1.68	2.41	No Data	1.90	3.30	2.39	2.84	2.12	No Data	2.20	3.20
Cadmium	0.59	0.50	0.65	1.00	No Data	1.00	0.96	0.94	0.60	0.45	No Data	0.12	<0.46
Chlordane*					No Data				0.007	0.007	No Data	0.007	<0.07
Chromium					No Data	25.6	35.5		27.5	20.3	No Data	17.5	21.7
Copper	34	46	83	28	No Data	41	63	59	55	40	No Data	31	46
Iron %	1.69	1.21	2.24	2.12	No Data	2.39	5.13	5.51	2.15	1.80	No Data	1.90	1.04
Mercury	0.11	0.15	0.15	0.10	No Data	0.07	0.18	0.16	0.11	0.07	No Data	0.06	0.10
	5.75	7.74		5.78	No Data			11.00	17.50		No Data		
Manganese	3223	205	526	453	No Data	425	632	448	485	372	No Data	308	327
Nickel					No Data	11	17		16	11	No Data	8	13
Oils & Grease	1000	1967		2075	No Data	2217	3450	3432	3432		No Data		
Lead	21	28	49	62	No Data	30	56	42	51	34	No Data	28	35
PCBs					No Data						No Data	0.26	<0.22
pp'-DDT					No Data				<0.005	<0.005	No Data	<0.005	<.05
pp'-DDD					No Data		<0.205		<0.005	<0.005	No Data	<0.005	<.05
pp'DDE					No Data				<0.005	<0.005	No Data	<0.005	<.05
TKN	1960	2614	2109	1399	No Data	1121	1136	1285	189	1495	No Data	1027	<1433
TOC%	2.64	3.76	3.68	2.67	No Data	2.93	4.22	4.65	2.61	1.91	No Data	1.77	2.70
Total Phosphorus		846	977	903	No Data	488	539	669	1136	929	No Data	776	789
Zinc	122	102	208	173	No Data	165	256	200	185	141	No Data	115	156
Total PAHs		<1.79	<1.89		No Data	<1.55	<1.47	<8.01	<3.68	<3.14	No Data	<3.06	<2.42

Green shading indicates values below the Lowest Effect Level

Yellow shading indicates values above the Lowest Effect Level and below the Severe Effect Level

Red shading indicates values above the Severe Effect Level

Mauve shading indicates reported detection limits above the Lowest Effect Level

*The detection limit used was higher than the LEL but well below the SEL sediment guideline

Table 2: Comparison of Contaminants in Keating Channel Sediment to Lake Ontario Sediment

ug/g	Keating Channel 2012			Lake Ontario Mississauga Basin			Nearshore 1002
	Mean	Min	Max	Mean	Min	Max	
As	3.2	1.0	4.0	17.9	ND	44.0	17.7
Cd	<0.46	0.<0.5	1.0	2.2	ND	5.8	2.2
Cr	21.7	6.0	36.0	38.9	4.2	63.7	38.9
Cu	46	11.0	74.0	58.6	3.7	108.6	41.9
Pb	35	8.0	71.0	74.3	5.2	144.9	56.1
Ni	12.5	4.0	21.0	58.0	7.5	100.2	27.0
Zn	156	37	253	244.4	11.2	455.4	170.0
Hg	0.1	0.01	0.15	0.6	0.0	1.4	0.2
N	<1433	<0.05	2700	3259.9	198.0	6950.0	
P	789	264.0	1220.0	883.8	112.0	1490.0	
Fe (%)	1.0	0.3	1.5	2.3	0.4	3.4	1.9
Mn	327	114	505	3341.2	224.0	12503.0	445.0
Al	-	-	-	1.0	0.1	1.6	-
PCBs	<0.22	<0.05	<0.5	0.001**			
PAHs***	ND	ND	ND				

* ND = not detected and the method detection limit.

** Represents a Lake Ontario wide average.

*** Data is for Total PAHs.

The report "Dredge Disposal Criteria for the Toronto CDF" (Golder Associates Ltd. 2003) summarizes the results of several toxicity tests performed on Keating Channel sediment that was placed in Cells 1 and 2. Toxicity tests on this material were conducted in 1995, 1998 and 1999 by the MOE and TRCA. This testing found no acute toxicity (i.e. mortality) in any of the test organisms, which included, mayflies, chironomid midges and fathead minnows although sediment concentrations of some metals were above the LEL's. Some reduction in growth of mayflies was noted in the early test on sediments from Cell 2. Follow-up toxicity testing on Cell 1 and 2 sediments showed no mortality to the test organisms and mayfly growth was not affected (i.e. equal to controls). The 2012 Keating Channel data shows that contaminant concentrations have changed little and are similar to the sediment concentrations in Cell 1 and 2 in 1995, 1998 and 1999 which were subjected to toxicity testing. It can be assumed that if toxic effects were not manifested at similar contaminant concentrations in 1990's there would be no toxicity issues from contaminant levels in 2012 Keating Channel sediment.

Benthic community assessment within the Keating Channel proper has not been undertaken due to annual removal of sediment from the channel. Any assessment of benthos from this area would likely conclude there is impairment associated with the yearly physical disturbance. Benthic community assessments of sediment around the mouth of the Keating Channel, which is the closest location to the channel proper, were conducted in 1995 MOE-TRCA and by Environment Canada in 2007 (Burniston and Waltho 2011). These studies found "densities of benthic organisms were highest (within the Inner Harbour) at the mouth of the Keating Channel with over 95% of the fauna comprised of oligocheates . The significantly higher density of oligocheates near the mouth of the Keating Channel does not appear to be related to contaminant levels. This is supported by the results of sediment toxicity testing which did not find any toxicity associated with the sediment. The oligocheate densities appear to be related mainly to the influx of sediment and higher organic matter from the Don River" (Golder Associates 2012).

The weight of evidence provided by the sediment chemistry, toxicity testing and benthic community assessment demonstrates the Keating Channel sediment does not pose an environmental risk. Comparison of sediment quality to non-AOC sites shows that Keating Channel sediment is similar or better in quality.

Conclusion

- Disposing of dredged material in open waters is not an environmentally benign practice. Historical methods of assessing suitability of sediment for open water disposal was based on mitigating environmental impacts purely from a contaminants perspective and did not consider the physical alterations to aquatic habitat. Considering the open water disposal of sediment as a beneficial use appears to be contrary to spirit and intent of the AOC process to restore environmental quality.
- Many Great Lakes jurisdictions, including Ontario, have restricted the open disposal of dredged materials. Many of these jurisdictions encourage the re-use of this material for a variety of applications including construction purposes and beach nourishment in the case of clean sand.
- Current approaches to assessing the environmental risk posed by sediment bound contaminants has progressed beyond the simple application of conservative chemical guidelines to predict environmental effects and includes the use of evidence based biological effects such as toxicity testing, benthic community structure and the potential for biomagnificaiton. In addition, the original assessment was wrongly applied to all areas within the AOC and not limited to maintenance dredging of navigational channels.
- Keating Channel sediment is less contaminated than sediment in the non-AOC areas of Lake Ontario's Mississuaga Basin and at the Environment Canada's reference nearshore station in the Oakville area.
- The application of more sophisticated biological testing to assess the environmental effects posed by sediment-bound chemicals within the AOC shows that there is low concern overall and that Keating Channel sediment is not a risk (Golder and Associates. 2012. Toronto and Region Area of Concern – Review of Sediment and Benthic Conditions).

For these reasons it is concluded that the "restrictions on dredging" within the Toronto and Region Area of Concern be re-designated as not impaired.

Figure 1: Toronto Inner Harbour and Tommy Thompson Park and Confined Disposal Cells 1, 2 and 3

FIGURE 2 : Map of Lake Ontario showing sampling stations for 1998 sediment survey and major depositional basins. (Source: Marvin, C.H. et al. J Great Lakes Res. 29(2):317-331 Internat. Assoc. Great Lakes Res., 2003)

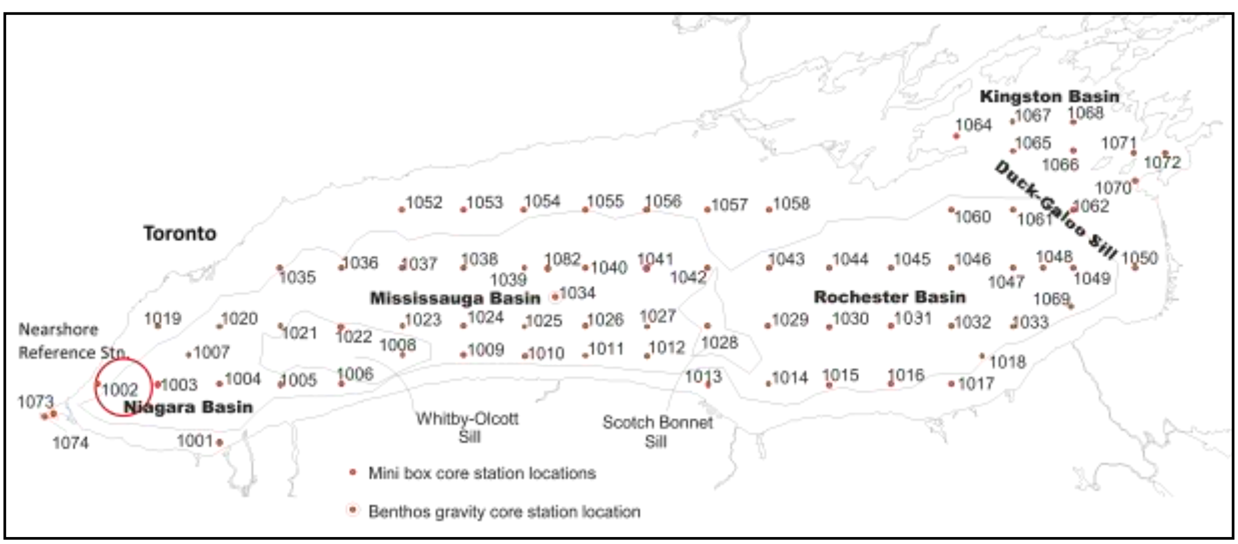
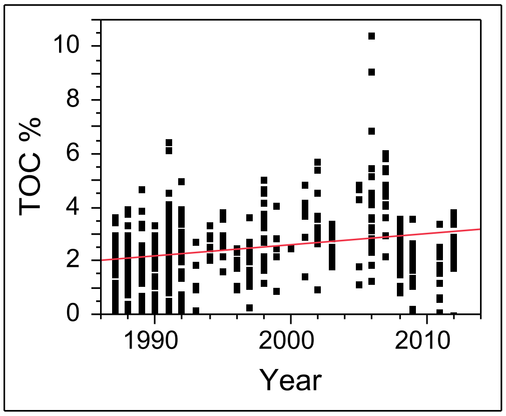
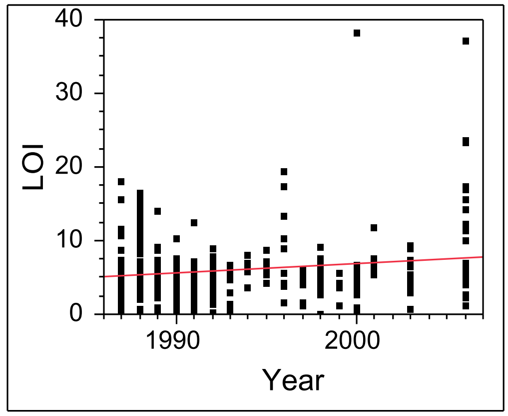


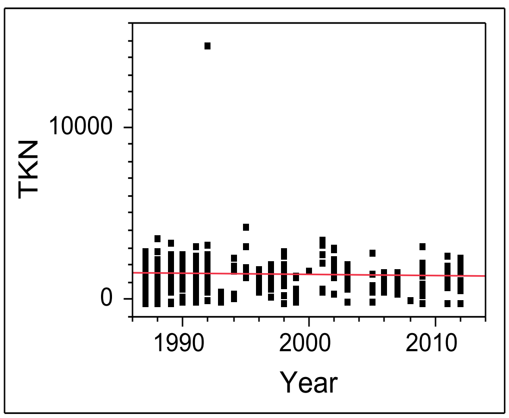
Figure 3: Keating Channel Sediment Quality Temporal Trends 1987-2012



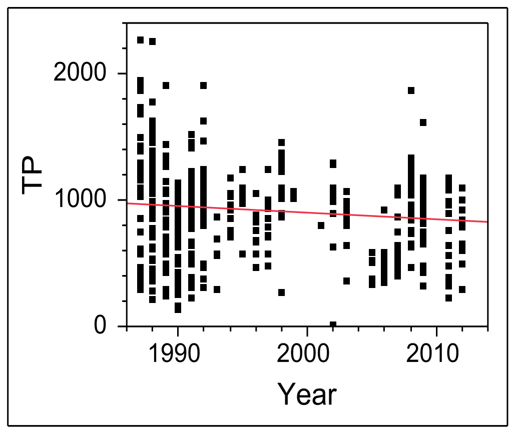
Bivariate Fit Total **Organic Carbon**
($R^2 = 0.07$)



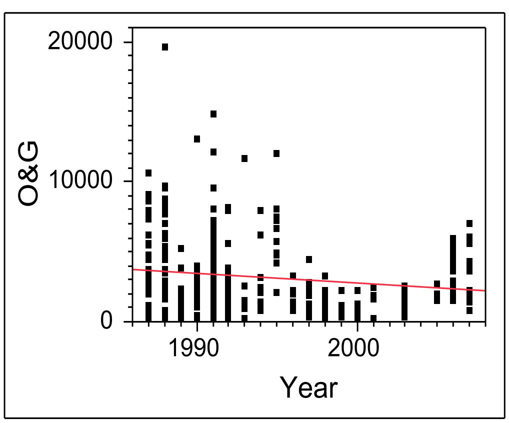
Bivariate Fit Loss **On Ignition**
($R^2 = 0.023$)



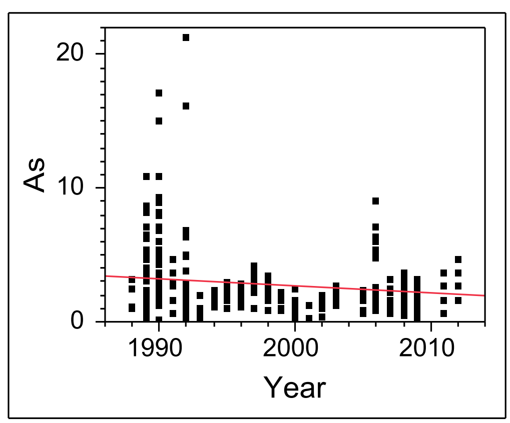
Bivariate Fit Total **Kjedhall Nitrogen**
($R^2 = 0.0025$)



Bivariate Fit Total **Phosphorous**
($R^2 = 0.015$)

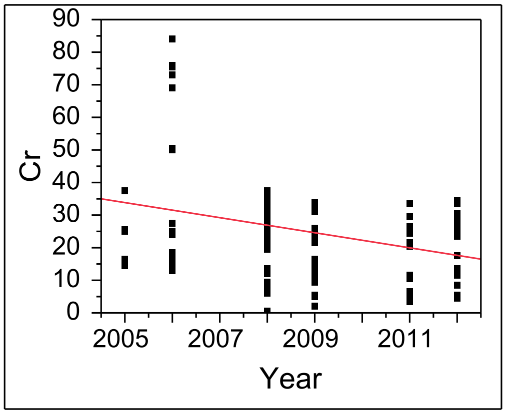


Bivariate Fit Oils **& Grease**
($R^2 = 0.024$)

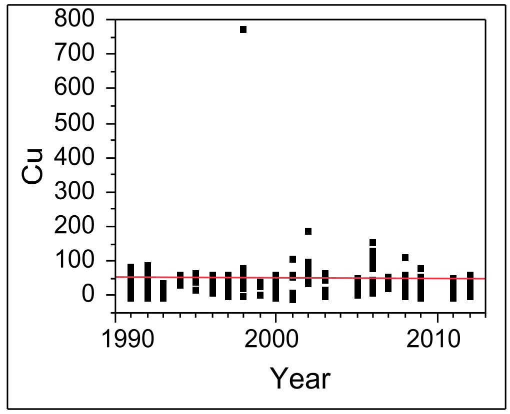


Bivariate Fit Arsenic
($R^2 = 0.03$)

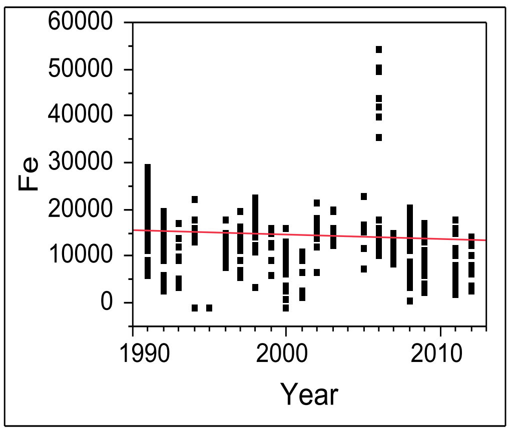
Figure 3 (continued): Keating Channel Sediment Quality Temporal Trends 1987-2011



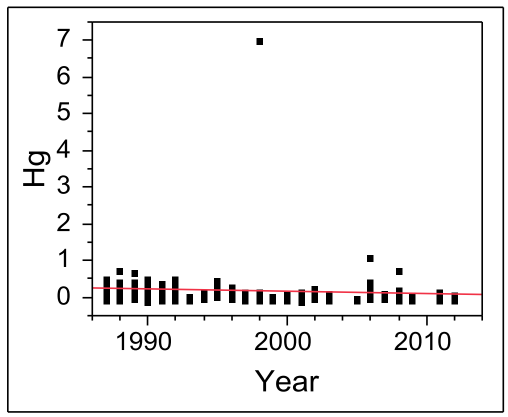
Bivariate Fit **Chromium** (R^2 = 0.102)



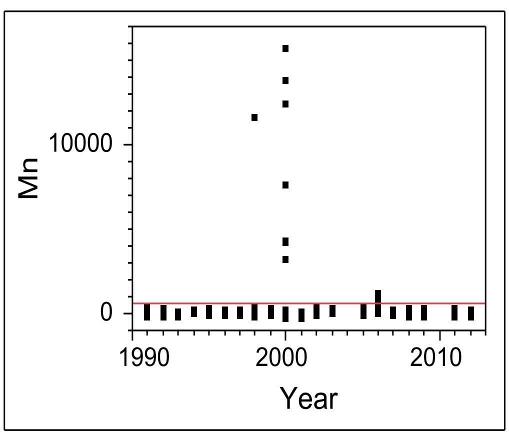
Bivariate Fit Copper (R^2 = 0.00085)



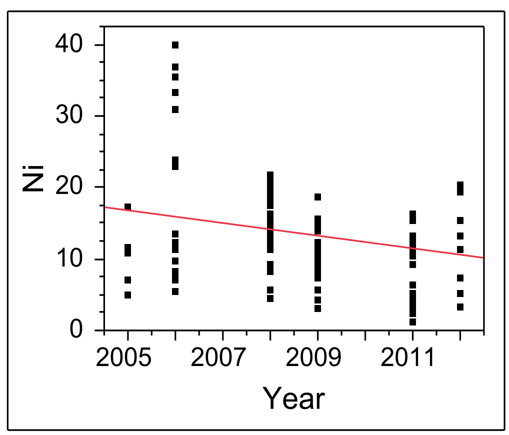
Bivariate Fit **Iron** (R^2 = 0.008)



Bivariate Fit **Mercury (**R^2 = 0.021)

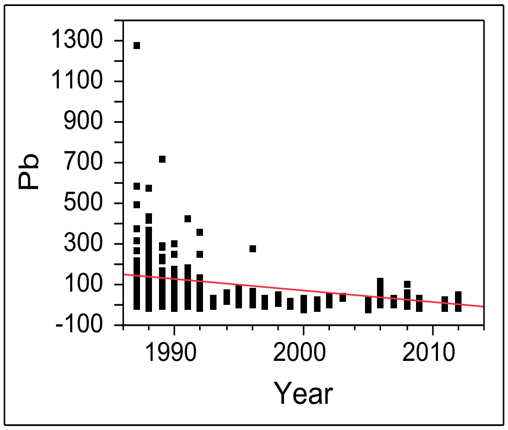


Bivariate Fit **Manganese** (R^2 = 0.024)

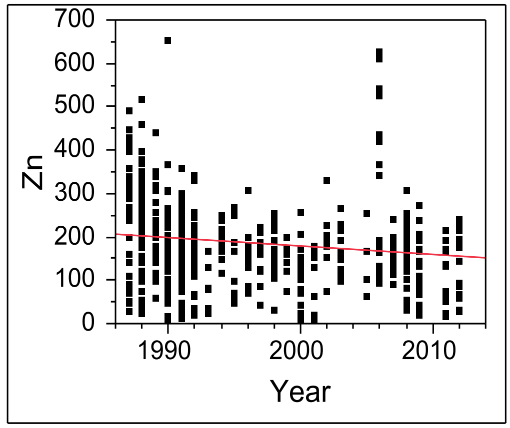


Bivariate Fit **Nickel** (R^2 = 0.066)

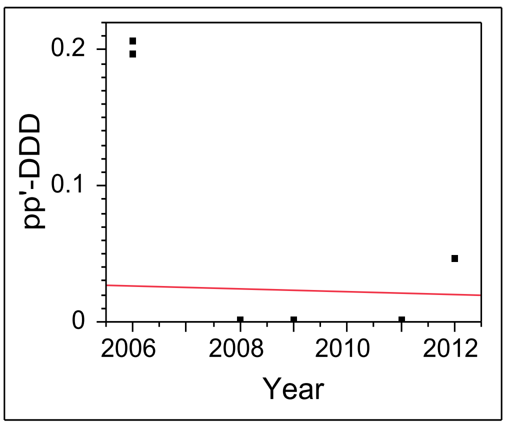
Figure 3 (continued): Keating Channel Sediment Quality Temporal Trends 1987-2011



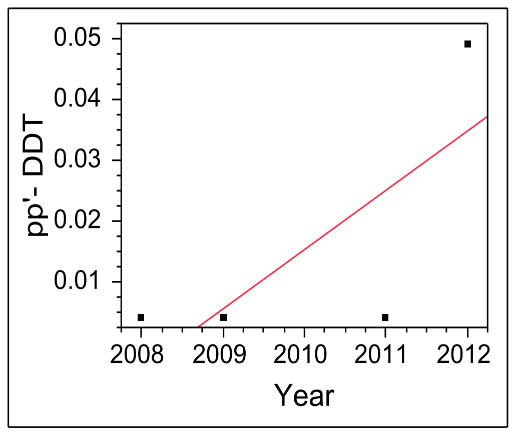
Bivariate Fit **Lead** (R^2 = 0.19)



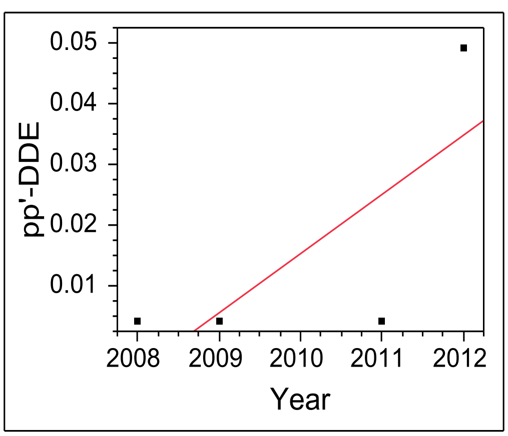
Bivariate Fit **Zinc** (R^2 = 0.026)



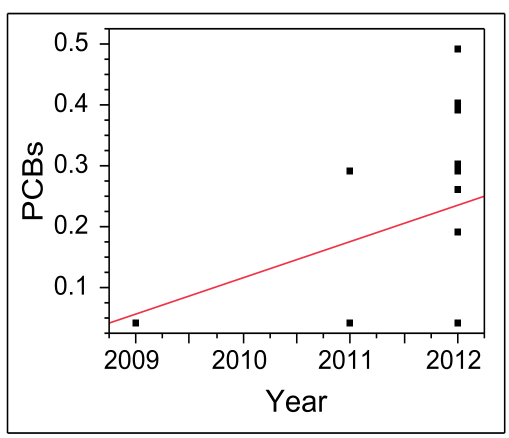
Bivariate Fit **pp-DDD** (R^2 = 0.0026)



Bivariate Fit **DDT** (R^2 = 0.55)



Bivariate Fit **pp-DDE** (R^2 = 0. 55)



Bivariate Fit **PCBs** (R^2 = 0.35)

References

Acres (Acres Consulting Ltd.) 1983. Keating Channel Environmental Assessment: Main Report.

Environment Canada and Ontario Ministry of the Environment. 1998 un-published. Review of Restrictions on Dredging.

Environment Canada and Ontario Ministry of the Environment. 2007. Canada-Ontario Decision-Making Framework for Assessment of Great Lakes Contaminated Sediments. Environment Canada Ontario Region and Ontario Ministry of the Environment.

Golder Associates Ltd. 2002. Report On Review of Sediment Conditions in the Lower Don River/Keating Channel and the Toronto Inner Harbour. Submitted to the Toronto and Region Conservation Authority, 5 Shoreham Dr., Toronto, Ontario.

Golder Associates Ltd. 2003. Report On Dredge Disposal Criteria for the Toronto CDF. Submitted to: Toronto and Region Conservation Authority, 5 Shoreham Drive, Toronto, Ontario.

Golder Associates Ltd. 2012. Toronto and Region Area of Concern. Review of Sediment and Benthic Conditions. Submitted to Environment Canada, Great Lakes Division, 4905 Dufferin Street, Toronto, Ontario.

Hayton, A., D. Persaud and R. Jaagumagi. 1992. Fill Quality Guidelines for Lakefilling in Ontario: Application of Sediment and Water Quality Guidelines to Lakefilling. Ont. Ministry of the Environment. Toronto. 20p.

Jaagumagi, R. and D. Persaud. 1996. An Integrated Approach to the Evaluation and Management of Contaminated Sediments. Ontario Ministry of Environment and Energy, Standards Development Branch, ISBN 0-7778-3845-1, Toronto, Ontario. 50 p.

Krantzberg, G and Montgomery, K. 2007. Restrictions on dredging as an impaired beneficial use under the Great Lakes Water Quality Agreement. Aquatic Ecosystem Health & Management, 10(1):117–124.

Marvin, C.H., M.N. Charlton, E.J. Reiner, T. Kolic, K. MacPherson, G.A. Stern, E. Braekevelt, J.F. Estenik, L. Thiessen and S. Painter. 2002. Surficial Sediment Contamination in Lakes Erie and Ontario: A Comparative Analysis. J. Great Lakes Res. 28 (3): 437-450.

Marvin, C.H., Charlton, M.N., Stern, G.A., Braekevelt, E., Reiner, E.J., and Painter, S. 2003. Spatial and Temporal Trends in Sediment Contamination in Lake Ontario. J. Great Lakes Res. 29(2):317-331.

Marvin, C.H., L. Grapentine and S. Painter. 2004. Application of a Sediment Quality Index to the Lower Laurentian Great Lakes. Environ. Monit. Assess. 91: 1-16.

Ontario Ministry of the Environment. 2008. Guidelines for Identifying, Assessing and Managing Contaminated Sediments in Ontario: An Integrated Approach. PIBS 6658e. May 2008.

Persaud, D., R. Jaagumagi and A. Hayton. 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. OMOE Report. 32pp

Persaud, D and W.D. Wilkins. 1976. Evaluating Construction Activities Impacting on Water Resources. Ont. Ministry of the Environment. 1976.

Portiss, R., Manager Monitoring Projects, Restoration Services, Toronto and Region Conservation Authority personal communicationOctober 23, 2013.