Contaminant Loadings and Concentrations to Hamilton Harbour:

2003-2007 Update

January 2010

Hamilton Harbour

RAP

Technical Team

Remedial Action Plan for Hamilton Harbour

Contaminant Loadings and Concentrations to Hamilton Harbour: 2003-2007 Update

January 2010

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Executive Summary

The Hamilton Harbour Remedial Action Plan (RAP) Stage 2 Update 2002 Report sets out water quality goals for the Harbour necessary for delisting. It also supplies initial and final net loading targets for sources of contaminant discharge into the Harbour. The final loading targets are estimated to be necessary and sufficient conditions for achieving the Harbour water quality goals based on the historically observed relationship between reductions in contaminant mass loadings and reductions in Harbour water contaminant concentrations.

To track loadings to the Harbour, the RAP produced the "1990-1996 Contaminant Loadings and Concentrations to Hamilton Harbour" in 1998. In 2004, the Hamilton Harbour Technical Team report continued this work and covered the period from 1996 to 2002. This update provides data for 2003 to 2007.

A loading is the total mass (kg) of a substance discharged to receiving water body over a specified time (a day). A contaminant mass loading is the product of a contaminant concentration (mg/L) and a flow (m^3/day) and hence can be affected by changes in either term.

Section 7 reports actual or measured loadings data (wastewater treatment plants and steel mills), and estimated or modeled loadings data (combined sewer overflows, urban runoff, creeks, and Cootes Paradise) by source. Section 8 repackages the data from the sources by contaminant to try to provide a "total loading" to the Harbour and Cootes Paradise. Readers need to keep in mind this total is in itself only an estimate.

The report does not provide an interpretation of the concentration and loading results. Interpretation of results is a follow-up activity to be conducted by the RAP Technical Team and others and will be published from time to time in separate reports.

The Hamilton Harbour RAP is assisted by: the Bay Area Implementation Team (BAIT), the Bay Area Restoration Council (BARC), and Hamilton Harbour scientists. The Hamilton Harbour RAP relies on BAIT for implementation of initiatives, BARC for public input, and scientists for ongoing scientific and technical advice. Participants on the RAP Technical Team assisting with this report were representatives of Environment Canada, Ontario Ministry of the Environment, City of Hamilton, Region of Halton, Conservation Halton, Hamilton Conservation Authority, Royal Botanical Gardens, U. S Steel Canada, and ArcelorMittal Dofasco. The contributions from these groups cannot be understated. The Hamilton Harbour RAP has met the expectations of the public-at-large and incorporated an ecosystem approach because of these organizations.

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1. Background

In the late 1980s, the International Joint Commission (IJC) identified 43 Areas of Concern in the Great Lakes basin where the beneficial uses of the water were considered impaired. Hamilton Harbour was designated as one of 17 Canadian Areas of Concern under Annex 2 of the Canada - United States Great Lakes Water Quality Agreement (GLWQA) (1978 – as amended 1987). The Agreement identifies the 14 beneficial use impairments as:

i. Restriction on fish and wildlife consumption
ii. Tainting of fish and wildlife flavour
iii. Degraded fish and wildlife populations
iv. Fish tumours or other deformities
v. Bird or animal deformities or reproductive problems
vi. Degradation of benthos
vii. Restrictions on dredging activities
viii. Eutrophication or undesirable algae
ix. Restrictions on drinking water consumption or taste and odour problems
x. Beach closings (Water contact sports)
xi. Degradation of aesthetics
xii. Added cost to agriculture or industry
xiii. Degradation of phytoplankton and zooplankton populations
xiv. Loss of fish and wildlife habitat

For each Area of Concern, the Governments committed to developing and implementing a Remedial Action Plan (RAP) to restore and protect environmental quality and beneficial uses. In Canada, the RAP program is a joint federal-provincial initiative under the Canada-Ontario Agreement respecting the Great Lakes Ecosystem (COA).

The RAP process involves: identifying environmental problems, determining sources and causes of problems (Stage 1); involving the public to establish community and stakeholder goals and objectives and reaching consensus on recommended actions, implementation plans and monitoring strategies (Stage 2); and implementing actions, and monitoring progress (Stage 3).

For the Hamilton Harbour Area of Concern (AOC), Stage 1 was completed in 1989 with a second edition produced in 1992. Stage 2 was completed in 1992, with an update finished in 2002. Stage 3, currently targeted for 2015, will not be written until Hamilton Harbour is ready to apply to be delisted as an AOC.

The Hamilton Harbour RAP is assisted by: the Bay Area Implementation Team (BAIT), the Bay Area Restoration Council (BARC), and Hamilton Harbour scientists. The RAP relies on BAIT for implementation of initiatives, BARC for public input, and scientists for ongoing scientific and technical advice. The contributions from these groups cannot be understated. The Hamilton Harbour RAP has met the expectations of the public-at-large and incorporated an ecosystem approach because of these organizations.

BAIT members represent the following 18 agencies and organizations: ArcelorMittal Dofasco, Bay Area Restoration Council, City of Burlington, City of Hamilton, Conservation Halton, Fisheries and Oceans Canada, Environment Canada, Hamilton Conservation Authority, Hamilton Harbour RAP Office, Hamilton Halton Home Builders'

Association, Hamilton Port Authority, Hamilton Waterfront Trust, McMaster University, Ontario Ministry of the Environment, Ontario Ministry of Natural Resources, Regional Municipality of Halton, Royal Botanical Gardens, and U. S. Steel Canada.

2. Description of the Area

Hamilton Harbour is a 2,150 hectare (ha) embayment of Lake Ontario connected to the lake by a single ship canal across the sandbar that forms the bay. The conditions in the Harbour reflect natural inputs, human activities, land uses, and drainage from the watershed of 49,400 ha (Figure 1). Cootes Paradise Marsh is a 250 ha, shallow area of both marsh and open water, discharging at an artificial opening into the west end of the Harbour called the Desjardins Canal.

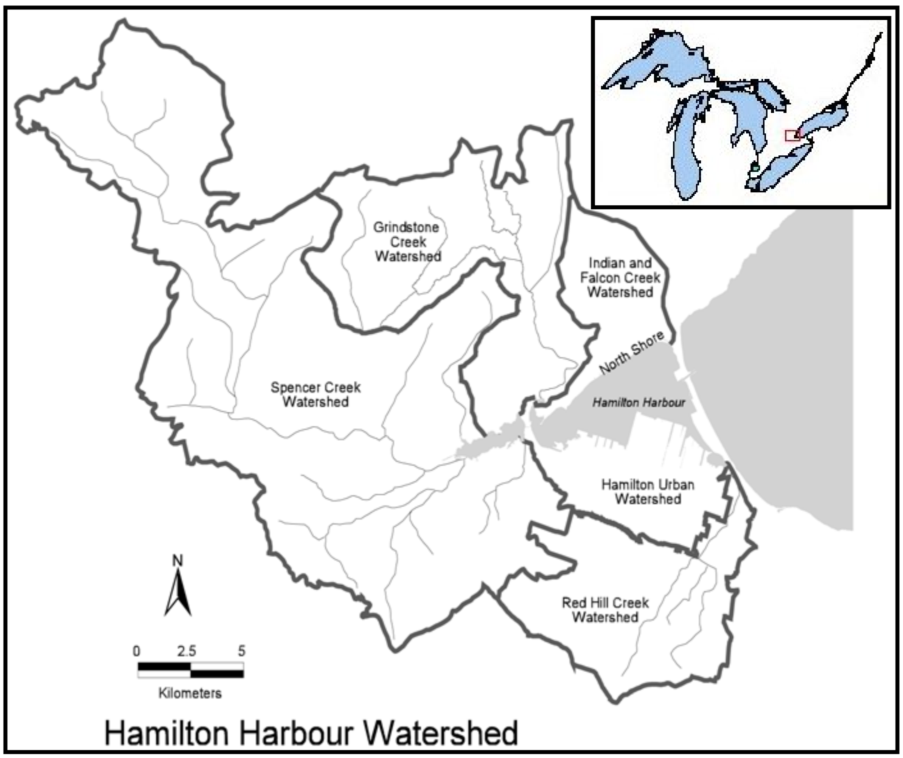

Figure 1. Hamilton Harbour Watershed Map

3. RAP Components

The Stage 2 Update 2002 divides the Hamilton Harbour RAP into seven components:

- Water Quality and Bacterial Contamination
- Urbanization and Land Management
- Toxic Substances and Sediment Remediation
- Fish and Wildlife
- Public Access and Aesthetics
- Education and Public Information
- Research and Monitoring

4. Purpose and Scope of a Loadings Report

A loading is the total mass (kg) of a substance discharged to receiving water body over a specified time (a day). A contaminant mass loading is the product of a contaminant concentration (mg/L) and a flow (m^3/day) and hence can be affected by changes in either term.

This report reports actual or measured loadings (wastewater treatment plants and steel mills), and estimated or modeled loadings (combined sewer overflows, urban runoff, creeks, and Cootes Paradise). As both types of loadings are used to try to provide a "total loading" to the Harbour and Cootes Paradise, readers need to keep in mind this total is in itself only an estimate. The direct comparison between actual and estimated loadings is artificial, but it is done to give a sense of the big picture.

Mass loading reductions can be achieved through reducing contaminant concentrations, reducing flows, or reducing both flow and concentration. This becomes significant when identifying where potential mass loading reductions may be achievable, since those flows which are a principally a function of rainfall may be either difficult or impossible to control (e.g. non-point sources such as creek or urban runoff). It is also important to keep this in mind when comparing year-to-year average contaminant mass loadings from non-point sources where flow is driven by rainfall. Not only will contaminant mass loadings vary directly as a result of changes in the flow term, but for many contaminants (e.g. suspended solids, phosphorus, metals) concentrations will also vary as a function of flow. This relationship increases the tendency for wet years to result in significantly higher non-point source mass loadings than dry years.

Although not attempted in this report, meaningful analysis of trends in non-point source contaminant mass loading to the Harbour is best accomplished by normalizing the results to diminish the year-to-year variability associated with wet and dry years. This increases the potential to discern any underlying trends that are (largely) independent of flow and which may be attributable to changes in factors such as land use or the adoption of improved management practices. This is a method that may be examined by the Technical Team for future reports.

The Stage 2 Update 2002 Report sets out water quality goals for the Harbour necessary for delisting (Table 1). It also supplies initial and final net loading targets for sources of contaminant discharge into the Harbour (Table 2). The final loading targets are estimated to be necessary and sufficient conditions for achieving the Harbour water quality goals based on the historically observed relationship between reductions in contaminant mass loadings and reductions in Harbour water contaminant concentrations.

It is important to note that it is the water quality goals which are of primary significance; the loadings targets are merely a means to this end. The two-step progression to final loading targets (Table 2) is designed to accommodate refinements based on additional observations of contaminant mass loading reductions and corresponding improvements in Harbour water quality. Periodic updates of receiving water quality contaminant concentrations are required by the RAP to track progress towards the water quality goals. Similarly, periodic updates of contaminant mass loading estimates are useful in assessing whether previously recommend management strategies are on track, or whether revisions are warranted. These could include changes in loading reduction targets as the result of an updated understanding of the relationship between contaminant mass loadings and receiving water quality in the Harbour. They could also include a change in strategy as the result of an improved understanding of the role of non-point source discharges, for example.

Table 1. Water Quality Goals for Hamilton Harbour

	Harbour Initial Goal	Harbour Final Goal	Cootes Paradise	Grindstone Creek Area	Beaches
Phosphorus concentration (µg/L)	34	17	60-70	60-70	
Un-ionized Ammonia concentration (mg/L)	<0.02	<0.02	<0.02	<0.02	
Chlorophyll a concentration (µg/L)	15-20	5-10	20	20	
Secchi Disk Transparency (m)	2	3	1.5	1	1.2
Minimum DO concentration (ppm)	>1	>4	>5	>5	
Submergent/emergent aquatic plant area (ha)	105	170	240	50	
Suspended Solids (ppm)			25	25	
Bacteria (E. coli organisms/ 100 mL water)					<100

Source: Stage 2 Update 2002 (pg. 27, Delisting Objective viii)

Table 2. Net Loading Targets in Kilograms per Day (kg/day)

	Phosphorus		Ammonia		Suspended Solids	
	Initial	Final	Initial	Final	Initial	Final
Woodward WWTP	140	60	2270	530	3750	900
Skyway WWTP	30	12	470	115	500	200
Dundas WWTP	5		22		28	
Waterdown WWTP	1		5		5	
CSOs	70	5	160	20	1400	200
Streams	90	65				
Industry (combined)			400	270		
Stelco (U. S. Steel)					4000	1500
Dofasco (ArcelorMittal)					3500	1500
Totals	**336**	**142**	**3327**	**935**	**13183**	**4300**

Source: Stage 2 Update 2002 (pg. 26, Delisting Objective viii)

In the context of the Hamilton Harbour RAP contaminant mass loading summaries have two fundamental uses:

- to guide management decisions as to where reductions in contaminant concentrations (or associated flows) will have the greatest relative effect on <u>Harbour water quality</u>; and
- to illustrate those situations where regulated effluent discharges achieve and maintain effluent concentration limits, but where ongoing flow increases would lead to increased contaminant mass loadings and hence a corresponding reduction in receiving water quality.

The first of these is to guide management decisions as to where reductions in contaminant concentrations (or associated flows) will have the greatest relative effect on Harbour water quality by apportioning the approximate loads from various types of sources (e.g. municipal and industrial point sources versus urban and rural non-point sources). This is a deliberately Harbour-centric perspective which views creeks only as channels which influence water quality in the Harbour by delivering water and contaminants from watersheds to it. Clearly, this perspective is very limited in that it does not consider creeks as water bodies in their own right and hence cannot be used to guide management decision-making for water quality improvements within watersheds themselves. It is entirely possible to achieve enormously significant water quality improvements in a small creek that will result in virtually no improvement to Harbour water quality merely because the flows from this tributary are a trivial component of total flows into the Harbour. This does not mean that such water quality improvements are not worthwhile from a local perspective, just that such local improvements cannot be expected to show measurable improvements to water quality in the Harbour as a whole. It should be remembered, however, that the cumulative improvements from numerous individual sites may make a measurable difference to the Harbour.

The other principal function of mass loading summaries is to illustrate those situations where regulated effluent discharges achieve and maintain effluent concentration limits, but where ongoing flow increases would lead to increased contaminant mass loadings and hence a corresponding reduction in receiving water quality. An obvious example of this would be a municipal WWTP which maintains effluent concentrations at a specific level, but which discharges increased volumes of treated wastewater as the result of population growth, and which consequently, has an adverse effect on Harbour water quality without efforts to change the treatment practices.

This report was initiated by the RAP Office with assistance from the Technical Team to:

- Obtain and summarize annual average concentrations and loadings for 2003-2007.
- Update long term trend graphs of contaminant loadings using available 2003-2007 data and estimates.
- Identify and document concerns or problems related to the reliability, consistency, and accuracy of loading estimates.

The data sources, methods for obtaining and reporting the data and procedure for estimating loadings are described in this report. Limitations in the approach or gaps in the data are identified. Results are presented in the form of updated tables and graphs of concentrations and loadings to Hamilton Harbour and Cootes Paradise.

The report does not provide an interpretation of the concentration and loading results. Interpretation of results are follow-up activities to be conducted by the RAP Technical Team and others.

For the remainder of this report "contaminant mass loading" will be shortened to "loading" or "contaminant loading" for convenience purposes.

In some cases, the concentrations provided were listed as < MDL or less than method detection limit. Due to the variety of techniques and agencies, it is not practical to list all of the method detection limits in the body of the report. As < MDL causes problems when trying to calculate loadings, for the purposes of this report, no attempt to calculate a loading was made in these cases.

5. Contaminants of Concern for Hamilton Harbour

The 1992 Stage 2 Report of the Hamilton Harbour RAP presents annual concentrations and loadings of selected contaminants to Hamilton Harbour and Cootes Paradise for the period from the mid-1970s to 1989. Table 3 lists the contaminants which were plotted as trend and pie charts in that report and briefly describes their environmental significance.

Mirex and DDT were among the organochlorine compounds identified as a local concern in the 1992 Stage 2 Report, but the report does not provide loadings or trends. The 1998 Status Report stated: "There is no source of mirex in the Hamilton Harbour watershed. Sources are in Niagara Falls and Oswego, New York. There is likely no source of DDT in the Hamilton Harbour watershed." (p. 26). Hence, this report does not include either of these compounds.

PCB was among the trace contaminants identified in the 1992 Stage 2 Report, but the report does not provide loadings or trends. The Hamilton Harbour RAP Toxic Substances Task Group did assign PCBs to an "A" list of toxic chemicals during the preparation of the Stage 2 Update 2002 Report; however, due to a lack of information this report does not include this compound. More information on PCBs in Hamilton Harbour can be found in the following reports:

> Labencki, T. 2008. An Assessment of Polychlorinated Biphenyls (PCBs) in the Hamilton Harbour Area of Concern (AOC) in Support of the Beneficial Use Impairment (BUI): *Restrictions on Fish and Wildlife Consumption*. ISBN: 978-0-9810874-0-5
>
> Labencki, T. 2009. 2007 Field Season in the Hamilton Harbour Area of Concern. PCB and PAH water monitoring undertaken by the Ontario Ministry of the Environment to support mass balance work by the Hamilton Harbour Remedial Action Plan (RAP) on PAH contamination at Randle Reef and PCB contamination in Windermere Arm. ISBN: 978-0-9810874-2-9

In the Stage 2 Update 2002 Report (p. 81), the Hamilton Harbour RAP Toxic Substances Task Group assigned chemicals or chemical classes of contaminants of concern into one of two lists. These classifications are based on the Task Group's assessments of the impacts of these contaminants on the Harbour. This classification by priority was designed to facilitate the allocation of monitoring, abatement, and remediation resources so that delisting criteria can be met in the shortest timeframe. The "A" list of contaminants includes compounds that are prevalent in the Harbour at levels that pose significant risk to fish and wildlife. The "B" list of contaminants includes some compounds that are highly toxic, but have not been demonstrated to be present in Hamilton Harbour at levels that threaten fish or wildlife. Any of the "B" list compounds may be designated as "A" list contaminants should current or future studies identify potential threats to the ecosystem due to these substances. See Appendix B for a full listing of the "A" and "B" list contaminants. A review of the "A" and "B" lists is proposed for 2010 by the RAP Technical Team.

During the production of the 1996-2002 report, Tÿs Theÿsmeÿer with the RBG alerted the Technical Team to a concern about the concentration levels of copper in sediments in Cootes Paradise and the Grindstone Creek Estuary. The Tech Team hypothesized that sources could include copper pipes and roofs in the area or residue from copper now used in brake pads instead of asbestos. This emerging issue should be followed up in future reports.

Table 3. Environmental Significance of Contaminants of Concern for Hamilton Harbour

Contaminant and Common Abbreviation	Environmental Significance
Ammonia (NH_3)	Depletes oxygen in the receiving water. Toxic to fish at high levels depending on the pH and temperature of receiving water.
Total Kjeldahl Nitrogen (TKN)	The TKN test measures ammonia and organic nitrogen. In many wastewaters and effluents, organic nitrogen will convert to ammonia.
Total Phosphorus (TP)	Stimulates nuisance algal growths, reducing water clarity and dissolved oxygen levels.
Total Suspended Solids (TSS)	High concentrations create sludge deposits and contribute to turbidity and colour. Many specific contaminants are carried with the solids. High concentrations bury and choke out aquatic life, and accelerates the rate of inflling in marshes.
Lead (Pb)	Toxic to aquatic life at high levels.
Iron (Fe)	Toxic to sensitive aquatic life at high levels.
Zinc (Zn)	Toxic to fish, aquatic life at high levels.
Phenolics	Measures total phenols. May taint fish. Chlorination during water treatment may produce taste and odour. May have a detrimental effect on human health at high concentrations.
Cyanide	Toxic to fish, aquatic life at high levels.
Polycyclic Aromatic Hydrocarbons (PAHs)	A class of organic compounds, some of which are carcinogens. Benzo(a)pyrene is a representative of heavy PAHs and naphthalene is a representative of volatile PAHs. These are the two of primary interest for this report.

6. Sources of Contaminants

The loading sources (or “pathways”) to Hamilton Harbour and Cootes Paradise identified in the 1992 Stage 2 Report, as well as a brief description of the nature of the source and the individual contributors to each source, are listed in Table 4 and 5, respectively. Air deposition, while certainly a pathway for contaminants into the Harbour, is not dealt with in this report. The RAP relies on organizations such as Clean Air Hamilton to provide the community with information on air deposition.

Lake Ontario was listed as a loading source in the 1992 Stage 2 Report, but it was dropped from the 1990-1996 Loadings Report by the RAP Technical Team. The flow of water that enters the Harbour from Lake Ontario through the Burlington Ship Canal is difficult to measure. In the winter there is a surging of the currents back-and-forth in the Canal. In the summer there is an exchange of water with the Lake by a distinct inflow of cold water along the bottom of the Canal into the Harbour and an outflow of warm water from the Harbour into the Lake. These and other flow related phenomena are studied by researchers at the National Water Research Institute (NWRI) to create models in order to better understand flows in the Harbour, the Canal, and out into Lake Ontario. The Technical Team was of the opinion that a net increase in contaminants through flows from Lake Ontario to Hamilton Harbour was unlikely. Further, collecting information to better address the issue would be costly and of little benefit since the lake is not a controllable source.

Table 4. Hamilton Harbour Loading Sources

Source	Source Description	Individual Contributors
Wastewater Treatment Plants (WWTPs)	Effluents from treatment plants following biological and chemical treatment	City of Hamilton • Woodward WWTP • Waterdown WWTP Region of Halton • Skyway WWTP
Steel Mills	Process and cooling waters discharged during production of steel	Dofasco Stelco Hamilton
Urban Runoff	Intermittent discharges from storm sewers for systems separately conveying sanitary sewage and storm runoff	City of Hamilton • Ancaster • Dundas • Hamilton (portions) • Stoney Creek (portions) • Waterdown Region of Halton • Aldershot • Hager-Rambo Creek diversion
Combined Sewer Overflows (CSOs)	Intermittent discharges from older sewer systems conveying both sanitary sewage and storm runoff	City of Hamilton
Creeks	Discharges from creeks in the Hamilton Harbour watershed	Main Tributaries • Red Hill Creek • Grindstone Creek
Cootes Paradise	A shallow area of marsh and open water discharges via a canal to the Harbour	See Table 5

Table 5. Cootes Paradise Loading Sources

Source	Individual Contributors
Wastewater Treatment Plants (WWTPs)	City of Hamilton • Dundas WWTP
Urban Runoff	City of Hamilton • Ancaster • Dundas • Waterdown (portions)
Combined Sewer Overflows (CSOs)	City of Hamilton
Creeks	Main Tributary • Spencer Creek

7 Loading Sources

7.1 Wastewater Treatment Plants (WWTPs)

The Region of Halton provides the RAP Office with data on the Burlington Skyway WWTP. It discharges into Hamilton Harbour in the northeast corner. As of 2002, the nominal design flow of the WWTP is 118 MLD (1 megalitre per day = 1000 m^3/day).

For the Skyway WWTP the Region of Halton provides: an average daily flow, an average concentration, and an average daily loading for each month. An annual average is calculated using the monthly loadings provided. Table 6 provides a summary of loadings to Hamilton Harbour from the Skyway WWTP.

Some results in the below tables are reported as “less than” MDL (< MDL); this indicates that the concentrations for at least one sample that year was below the method detection limit used at that time. This causes problems when trying to calculate loadings, so for the purposes of this report, no attempt to calculate a loading was made in these cases.

Table 6. Skyway WWTP Final Effluent Contaminant Loadings (kg/day)

SKYWAY WWTP	1996	1997	1998	1999	2000	2001	2002
Ammonia (NH_3-N)	720	878	508	58	60	133	179
TKN	839	1014	644	190	197	272	330
Total Phosphorus	48	24	20	18	19	15	17
Total Suspended Solids	549	524	435	554	714	527	461
Lead	< MDL	0.1	< MDL				
Iron	no data	50.2	65.8	97.8	156.4	53.2	135.0
Zinc	2.29	1.56	1.62	< MDL	1.91	2.16	3.14
Phenolics *	< MDL			no data	< MDL		
Cyanide	no data						
PAH – Naphthalene	0.082	< MDL		no data	< MDL		
PAH – Benzo(a)pyrene	< MDL			no data	< MDL		

SKYWAY WWTP	2003	2004	2005	2006	2007
Ammonia (NH_3-N)	195	92	64	31	27
TKN	342	216	159	137	151
Total Phosphorus	13	8	11	12	20
Total Suspended Solids	567	293	393	373	420
Lead	< MDL				
Iron	64.9	53.2	55.7	47.7	56.8
Zinc	3.57	2.80	3.60	2.02	2.82
Phenolics *	< MDL	no data			
Cyanide	no data				
PAH – Naphthalene	< MDL	no data			
PAH – Benzo(a)pyrene	< MDL	no data			

Source: Regional Municipality of Halton (1996-2002, T. Leyburne) (2003-2007, S. English)
* Skyway data is for strictly phenol not phenolics, which could be a variety of compound variations
< MDL = concentrations were less than the method detection limit used, therefore not able to calculate

The City of Hamilton provides the RAP Office with data on three WWTPS: Woodward, Dundas, and Waterdown. The Woodward WWTP discharges into Red Hill Creek with a nominal design flow of 400 MLD. The Dundas (King St) WWTP discharges into Cootes Paradise with a nominal design flow of 18 MLD. All loadings for the Dundas WWTP are captured by the Cootes Paradise loading for the purposes of calculating a total loading to the Harbour. The Waterdown (Main St) WWTP discharges into Grindstone Creek with a nominal design flow of 2.7 MLD. All loadings for Waterdown WWTP are captured by the Grindstone Creek loadings for purposes of calculating a total loading to the Harbour.

For each of its three WWTPs the City of Hamilton provides: an average daily flow, an average concentration, and an average daily loading for each month. An average daily loading is calculated for each year using the monthly loadings provided. Table 7 provides a summary of loadings to Hamilton Harbour from the Woodward WWTP. Table 8 provides a summary of loadings to Cootes Paradise from the Dundas WWTP. Table 9 provides a summary of loadings to Grindstone Creek from the Waterdown WWTP.

Table 7. Woodward WWTP Final Effluent Contaminant Loadings (kg/day)

WOODWARD WWTP	1996	1997	1998	1999	2000	2001	2002
Ammonia	3962.1	4228.5	3856.9	4516.8	3943.1	2925.3	3175.2
TKN	5030.3	5173.5	4758.6	5249.2	4970.8	3859.8	3812.0
Phosphorus	143.2	159.9	168.5	165.6	261.0	239.4	197.7
Suspended Solids	5751.1	6939.2	7035.7	6580.2	8311.8	8442.7	6567.4
Lead	27.1	34.1	< MDL	14.5	6.9	< MDL	< MDL
Iron	472.3	483.0	1185.8	580.3	527.1	552.9	500.5
Zinc	34.9	32.8	12.4	14.9	17.3	11.8	15.3
Phenolics *	no data						
Cyanide **	no data	44.8	26.6	14.0	23.1	29.5	27.5
PAH – Naphthalene	no data						
PAH – Benzo(a)pyrene	no data						

WOODWARD WWTP	2003	2004	2005	2006	2007
Ammonia (NH_3-N)	2873.8	3288.7	2752.5	2062.4	1679.5
TKN	3337.5	3971.2	3350.7	2710.6	2036.1
Total Phosphorus	164.9	217.2	238.6	175.9	142.8
Total Suspended Solids	5744.2	7765.8	7251.7	4725.7	3336.1
Lead	1.3	1.8	1.1	< MDL	0.3
Iron	339.4	690.2	357.3	279.4	195.0
Zinc	20.0	17.9	17.8	16.8	11.4
Phenolics	no data	1.7	2.0	1.6	no data
Cyanide	30.93	22.73	25.62	25.31	no data
PAH – Naphthalene	no data				
PAH – Benzo(a)pyrene	no data				

Source: City of Hamilton (1996-2002, A. Nuxoll) (2003-2007, A. Khan)
* For 1996-2002 there were only two months for which data was provided – not enough to include in this report. The two concentrations given for phenol were ≤ 0.003 mg/L.
** 1999-2002 Cyanide values are estimates using a non-weighted average of plant flows
< MDL = concentrations were less than the method detection limit used

Table 8. Dundas WWTP Final Effluent Contaminant Loadings (kg/day)

DUNDAS WWTP	1996	1997	1998	1999	2000	2001	2002
Ammonia	5.2	5.4	3.3	9.7	6.1	13.5	12.9
TKN	22.2	22.8	22.3	26.0	24.4	34.5	33.8
Phosphorus	5.7	3.9	5.3	6.8	5.5	5.0	3.6
Suspended Solids	35.4	21.5	24.3	18.2	34.0	35.4	28.3
Lead	1.3	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Iron	3.7	4.1	2.1	9.13	6.6	5.9	4.4
Zinc	< MDL	1.0	0.3	0.8	0.8	0.7	0.5
Phenolics	no data						
Cyanide	no data						
PAH – Naphthalene	no data						
PAH – Benzo(a)pyrene	no data						

DUNDAS WWTP	2003	2004	2005	2006	2007
Ammonia (NH_3-N)	6.2	1.3	1.9	8.3	6.1
TKN	data not available at time of publication				
Total Phosphorus	3.1	2.7	3.7	3.9	3.5
Total Suspended Solids	17.7	13.3	13.9	17.7	14.1
Lead	data not available at time of publication				
Iron	data not available at time of publication				
Zinc	data not available at time of publication				
Phenolics	no data				
Cyanide	no data				
PAH – Naphthalene	no data				
PAH – Benzo(a)pyrene	no data				

Source: City of Hamilton (1996-2002, A. Nuxoll) (2003-2007, A. Khan)
< MDL = concentrations were less than the method detection limit used

Table 9. Waterdown WWTP Final Effluent Contaminant Loadings (kg/day)

WATERDOWN WWTP	1996	1997	1998	1999	2000	2001	2002
Ammonia	3.0	0.6	3.2	9.1	12.2	5.4	5.3
TKN	4.9	4.2	7.1	12.8	16.2	9.6	9.3
Phosphorus	0.6	0.7	1.1	1.7	1.0	1.0	0.6
Suspended Solids	5.2	6.2	4.8	4.3	5.2	7.4	5.2
Lead	0.1	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Iron	0.4	0.6	0.4	0.4	0.6	1.2	0.7
Zinc	< MDL	0.3	0.1	0.1	0.1	0.1	0.09
Phenolics	no data						
Cyanide	no data						
PAH – Naphthalene	no data						
PAH – Benzo(a)pyrene	no data						

WATERDOWN WWTP	2003	2004	2005	2006	2007
Ammonia (NH_3-N)	3.2	0.4	1.1	0.5	3.6
TKN	data not available at time of publication				
Total Phosphorus	0.7	0.4	0.4	0.6	1.8
Total Suspended Solids	3.2	2.4	2.9	5.0	5.6
Lead	data not available at time of publication				
Iron	data not available at time of publication				
Zinc	data not available at time of publication				
Phenolics	no data				
Cyanide	no data				
PAH – Naphthalene	no data				
PAH – Benzo(a)pyrene	no data				

Source: City of Hamilton (1996-2002, A. Nuxoll) (2003-2007, A. Khan)
< MDL = concentrations were less than the method detection limit used

Comments

- Both Woodward and Skyway WWTPs have secondary bypasses to prevent the secondary processes from washing out under high flows during wet weather periods. The secondary bypass discharges receive primary treatment and disinfection of the before reaching Hamilton Harbour. However, it was felt by the Technical Team that as these discharges represents such a small percentage of the total load to the Harbour, that they will not be incorporated into this report. For information purposes only, the table below shows the number of annual secondary bypass occurrences and the duration of the bypasses in hours; however it should be noted that the loadings may not be proportional to their duration due to variations in concentrations and flows.

Year	Woodward WWTP # of Bypass Occurrences (duration in hours)		Skyway WWTP # of Bypass Occurrences (duration in hours)	
	Plant	Secondary	Primary	Secondary
1996	included in CSO data	34 (328 hrs)	0 (0 hrs)	31 (212 hrs*)
1997	included in CSO data	59 (574 hrs)	0 (0 hrs)	26 (144 hrs*)
1998	included in CSO data	68 (740 hrs)	0 (0 hrs)	35 (114 hrs)
1999	included in CSO data	0 (0 hrs) **	0 (0 hrs)	7 (8.25 hrs)
2000	included in CSO data	62 (676 hrs)	1 (4 hrs)	13 (64.65 hrs)
2001	included in CSO data	62 (1557 hrs)	0 (0 hrs)	18 (73.95 hrs)
2002	included in CSO data	31 (271 hrs)	0 (0 hrs)	13 (24.88 hrs)
2003	included in CSO data	data not available at time of publication	3 (3.50 hrs)	17 (102.75 hrs)
2004	included in CSO data	data not available at time of publication	0 (0 hrs)	5 (37.40 hrs)
2005	included in CSO data	data not available at time of publication	0 (0 hrs)	12 (105.70 hrs)
2006	included in CSO data	data not available at time of publication	2 (11.62 hrs)	15 (119.77 hrs)
2007	included in CSO data	data not available at time of publication	1 (3.00 hrs)	8 (60.17 hrs)

* Region of Halton derived these durations using back-calculations as the actual values were not available.

** City of Hamilton confirmed this number. There were plant bypasses, but no recorded secondary bypasses.

7.2 Steel Mills

The Municipal-Industrial Strategy for Abatement (MISA) regulatory program, including the Iron and Steel Sector regulations, was passed to work towards the virtual elimination of toxic contaminants in industrial discharges into Ontario's waterways. The MISA effluent regulation (Environmental Protection Act, Ontario Regulation 214/95, Effluent Monitoring and Effluent Limits – Iron and Steel Manufacturing Sector) requires the reporting of gross effluent loadings. Limits were set for gross effluent loadings of: benzo[a]pyrene and naphthalene (PAHs), total cyanide, ammonia plus ammonium, total suspended solids, lead, zinc, phenolics, benzene, oil and grease, but not iron or phosphorus.

However, for the Hamilton Harbour RAP it is of interest to understand the net contribution of contaminants for each source. ArcelorMittal Dofasco and U. S. Steel Canada (formerly Stelco) take water from the Harbour, it goes through a screening filter, it is used in their facilities (some contacts the product, some doesn't contact the product (non-contact)), contact water is treated, and then both non-contact waters and the treated contact waters are discharged back to the Harbour again. Net loadings are calculated by subtracting the background loadings measured in Harbour intake water from the gross effluent loadings measured from what goes back into the Harbour. This can result in the reporting of a negative loading; it would indicate the industry removed more of the contaminant from the water than they put back through their effluent stream. This approach recognizes water withdrawn from the Harbour by the mills for steel making may be the cause of contaminants measured in the effluents they discharge. Very small positive and negative values can also be simply caused by analytical error in the measurement process, especially if the concentrations are close to the method detection limit. ArcelorMittal Dofasco and U. S. Steel Canada provided the RAP Office with net loadings for 1996-2007, including iron and phosphorus, which they measure at the request of the RAP.

Net loadings are calculated from measurements at a number of discharge points. The effluent and intake sampling points included in both ArcelorMittal Dofasco and U. S. Steel Canada's numbers are listed in Table 10 and 11, respectively.

Table 10. ArcelorMittal Dofasco - Effluent and Intake Sampling Points

MISA Control Point	Location	Description
0100	East Boat Slip Sewer	Cooling Water Effluent
0200	Ottawa Street Slip	Mixture of Dofasco and City of Hamilton discharges
0300	#1 Boiler House	Cooling Water Effluent
0400	West Bayfront Sewer	Merged Effluent
0600	Primary Wastewater Treatment Plant	Process Effluent
0800	Blast Furnace Recycle Blowdown	Process Effluent
1101	#1 Acid Regeneration Plant	Process Effluent
1200	#2 Boiler House	Cooling Water Effluent
1700	#2 Hot Mill & Melt Shop Sewer	Cooling Water Effluent
2000	#2 Hot Mill Plant Blowdown	Process Effluent
2500	Electric Arc Furnace Cooling Water	Cooling Water Effluent
2700	#6 Pickle Line Cooling Water Discharge	Cooling Water
2800	#2 Tandem Cooling Water Discharge	Cooling Water
0500	North End of property between boatslip and Ottawa Street Slip	Baywater Intake

Table 11. U. S. Steel Canada - Effluent and Intake Sampling Points

MISA Control Point	Location	Description
0100	West Side Open Cut	Cooling Water Effluent
0200	Northwest Outfall	Cooling Water Effluent
0400	North Outfall	Merged Effluent
0601	East Side Filter Plant	Process Effluent
0602	#1 60 Inch Sewer	Cooling Water Effluent
1100*	#2 Rod Mill	Process Effluent
1600	# 2 Bayshore Pumphouse	Intake

* Control Point 1100 discontinued with shut down of #2 Rod Mill (~ 2007)

Tables 12 and 13 summarize the net daily loadings data reported by ArcelorMittal Dofasco and U. S. Steel Canada for 1996-2007. As this is net data not gross, values can be reported as a negative value. This occurs when the water the industry takes in from the Harbour has more of the contaminant in it than the water the industry returns to the Harbour.

Table 12. Average Net Daily Loadings to Hamilton Harbour from ArcelorMittal Dofasco (kg/day)

ARCELORMITTAL DOFASCO	1996	1997	1998	1999	2000	2001	2002
Ammonia	356	333	155	152	94	54	34
Phosphorus	10	-1	10	-7	3	-8	-9
Total Suspended Solids	1626	2191	890	1168	1069	812	823
Lead	-0.2	0.8	0.1	0.07	0.4	0.2	0.4
Iron	540	371	70	96	119	86	61
Zinc	27	11	4	5	8	11	11
Phenolics	8.4	2.2	0.8	1.4	1.6	1.4	1.1
Cyanide	23.1	3.3	0.1	6.4	5.1	7.6	0.7
PAH – Naphthalene	0.2	-0.002	-0.01	0.02	-0.0003	0	0
PAH – Benzo(a)pyrene	0.1	0	0	0	-0.002	0	0

ARCELORMITTAL DOFASCO	2003	2004	2005	2006	2007
Ammonia	-118	53	46	89	202
Phosphorus	8	20	14	-13	9
Total Suspended Solids	840	1187	1857	1135	1648
Lead	0.6	0.6	1.6	1.5	4.0
Iron	79	201	200	7.4	581
Zinc	27	9	9	7	14
Phenolics	0.4	0.9	1.1	2.4	0.9
Cyanide	0.2	-2.7	0.5	0.8	1.1
PAH – Naphthalene	-0.01	0.00	0	-0.02	-0.01
PAH – Benzo(a)pyrene	-0.007	0.011	0	-0.003	-0.001

Source: Dofasco (1996-2002, C. McGinlay) ArcelorMittal Dofasco (2003-2007, S. Rajkumar)
Note: As this is net data not gross, values can be reported as a negative value.

Table 13. Average Net Daily Loadings to Hamilton Harbour from U. S. Steel Canada (kg/day)

U. S. STEEL CANADA	1996	1997	1998	1999	2000	2001	2002
Ammonia	75.7	-10.8	-13.3	-36.4	-27.3	3.6	-28.6
Total Phosphorus	36.2	9.0	18.2	7.6	0.7	-3.4	-6.5
Total Suspended Solids	6820	2658	4175	849	314	293	-1228
Lead	3.60	-0.97	0.22	0.026	0.43	-0.34	0.20
Iron	no data		134	87	17	2	-20
Zinc	29.7	3.4	4.5	-1.5	4.0	6.2	5.2
Phenolics	5.97	4.05	0.32	1.42	-0.21	1.02	-0.26
Cyanide	8.0	7.1	12.1	15.4	12.8	6.7	0.8
PAH – Naphthalene	-0.01	0.002	-0.06	-0.03	-0.0002	-0.001	-0.1
PAH – Benzo(a)pyrene	0.002	-0.004	0.006	-0.02	-0.07	0.006	0.02

U. S. STEEL CANADA	2003	2004	2005	2006	2007
Ammonia	-64.0	-16.9	12.5	28.9	31.2
Total Phosphorus	-3.5	2.2	3.0	6.0	3.5
Total Suspended Solids	-605	-532	762	32	-736
Lead	-0.007	0.010	0.12	0.056	0.017
Iron	24	79	138	93	90
Zinc	0.2	6.1	18.9	1.3	3.3
Phenolics	0.10	1.30	0.09	-0.01	-0.01
Cyanide	1.0	2.6	1.0	1.6	1.2
PAH – Naphthalene	-0.03	0.05	0.05	-0.01	-0.003
PAH – Benzo(a)pyrene	0.006	-0.007	-0.002	-0.007	0.041

Source: U. S. Steel Canada (A. Sebestyen)
Note: As this is net data not gross, values can be reported as a negative value.

7.3 Combined Sewer Overflows (CSOs)

Combined sewers in Hamilton convey both sanitary sewage and storm runoff. This is typical of older communities. As the City of Burlington has only separated sewers, there are no CSO inputs to Hamilton Harbour from their community. Originally, during rainfall events, Hamilton's 23 CSOs discharge this mixed, untreated effluent into the natural environment, either a creek or directly into the Harbour. The City of Hamilton embarked on a combined sewer overflow control program, starting with the construction of CSO tanks at Bayfront Park and James Street, which began operation in 1994. CSO tanks were also used at Main-King and Eastwood Park, which began operation in 1998. These CSO tanks allow untreated system overflow to be held during a storm event and sent to the Woodward WWTP once the plant can deal with the flows. Overflows are still possible, even in tanked locations. If this system was ever closed off from overflows, backups into homes and businesses might occur during larger storm events.

The following 5-paragraph methodology explanation on how CSO loadings will be calculated in this report versus the 1998 report was written by Mark Bainbridge of the City of Hamilton for use in this report (Mark Bainbridge, personal communication, December 2003).

> Methodology employed for the CSO (Combined Sewer Overflow) component of the Remedial Action Plan (RAP) 1990-1996 Contaminant Loadings Report was based on a generic formula developed to estimate CSO loadings to Hamilton Harbour and Cootes Paradise. This formula is dependent on information that can now be replaced by updated field data and modelling techniques currently used by the City of Hamilton to plan future improvements for wastewater handling and treatment. It is recommended that these new techniques be utilized to improve the loadings estimate under the new report developed for 1996 to 2002.
>
> CSO quality data is now being collected at three CSO tank locations, Eastwood Park, Bayfront Park, and Main-King. This provides a set of information that details the quality parameters for CSO, specific to Hamilton locations. Previously, the loadings report was attempting to estimate the quality of CSO by sampling wastewater at the Woodward Wastewater Treatment Plant and approximating stormwater concentration with literature values. Site sampling at CSO locations will reduce the level of error associated with reporting the quality of CSO flow. CSO characterization has also been refined through the development of a combined sewer system (CSS) model, powered by the U.S. EPA Storm Water Management Model (SWMM). This model is a comprehensive water quantity and quality simulation developed primarily for urban areas, including CSS. Several field monitoring operations were initiated to calibrate the current city model in the 1990's. Additional calibration information collected in the future will continually improve the accuracy of the model. The CSO sampling data being collected at the three tanks is incorporated to provide loading information relevant to the RAP loadings report.
>
> The numerical results obtained through the utilization of modelling and field sampling data will improve our ability to more accurately estimate loadings to the Harbour attributed to CSO events. The new tools that have been developed will provide us with several key advantages including an accounting of improvements

that have reduced CSO flow to the natural environment. The CSS model accounts for the positive impact that regulator adjustments and new CSO tanks have made on overall Harbour loadings. In addition, the model has the ability to detail system responses to all rainfall events no matter how big or small. Comparing the results of the original loadings report with an updated loadings report will be difficult due to the influence of this change in method. For this reason model runs will date back to 1990 and show the difference between each approach. It is anticipated that future reports will use the modelling method exclusively.

In summary, a single generic loadings calculation has many shortfalls when dealing with a complex CSS such as the one operating in the City of Hamilton. New tools and programs are now in place to provide better estimates of CSO loadings to Hamilton Harbour and Cootes Paradise. The most accurate reporting of loadings from CSO sources will only be possible when flow monitoring and sampling takes place at each and every outfall. Until this time, the best possible method of estimation should take advantage of the sampling programs that currently exist in the city. It should also take advantage of the most up to date mathematical modelling process that we have available. Installing this new method of quantifying loadings to the Harbour will improve the accuracy of the numbers that are reported. Increased accuracy will help us better understand our achievements and progress toward the cleanup of Hamilton Harbour and Cootes Paradise.

1990-1996 CSO loadings to Hamilton Harbour were based on estimates available at that time. Since then the City of Hamilton has been able to utilize new tools that more accurately estimate CSO contributions. The City continues to work toward implementation of a larger monitoring program that could eventually provide loadings to Hamilton Harbour and Cootes Paradise based on site specific field measurements at each CSO location.

Using the new model described above, the City of Hamilton provided: average measured CSO contaminant concentrations (Table 14), estimated Hamilton Harbour and Cootes Paradise CSO volumes, and estimated Hamilton Harbour and Cootes Paradise CSO daily loadings. The model was run according to OMOE F-5-5 Wet Weather criteria, which covers the period between April – October 31 (214 days) of each year. In order to compare numbers to the rest of the sources in this report, the rainfall and volume (Table 15) provided were adjusted by a factor of 365/214 to account for the whole year.

Table 14. Average CSO Contaminant Concentrations (mg/L)

SS	110.9 *
TP	2.13 *
Ammonia	5.4 *
TKN	1.3 *
Pb	0.027 *
Fe	4.62 **
Zn	0.15 *

* Average of Measured Contaminant Concentrations from Hamilton CSO Tank Influent events in 2002 and 2003.
** Average Contaminant Concentration taken from 1990-1996 Contaminant Loadings and Concentrations to Hamilton Harbour Report (June, 1998).

Table 15. Estimated Hamilton Harbour and Cootes Paradise CSO Volumes (m^3/yr)

Year	**Rainfall Volume** (mm/yr) [1]	**Hamilton Harbour CSO Volume** (millions of m^3/yr) [1]	**Cootes Paradise CSO Volume** (million of m^3/yr) [1]
1996	931.1	13.76	1.81
1997	532.3	7.38	1.04
1998 [3]	560.3	7.04	0.29
1999	624.4	8.33	0.40
2000	776.1	9.84	0.26
2001	974.2	11.78	0.47
2002	790.7	10.15	0.34
2003	902.5 [2]	7.16	0.14
2004	951.8 [2]	4.38	0.58
2005	992.9 [2]	12.56	0.90
2006	1033.3 [2]	5.88	0.50
2007	702.2 [2]	1.26	0.03

[1] Values provided by the City from the combined sewer system simulations only cover the period April 1 to October 31 of each year. These values here have been increased by a factor of 365/214 to account for the whole year for the purposes of this report.
[2] 2003-07 Rainfall volume direct from source – not increased by factor as above. Canadian Daily Climate Data (http://www.climate.weatheroffice.ec.gc.ca/Welcome_e.html) Station 6153194 YHM
[3] Main-King and Eastwood Park CSO Tanks began operation in 1998.

Equation 1 shows how the estimated contaminant loadings are calculated by the RAP Office using the adjusted CSO volumes from Table 15. The contaminant loadings for Hamilton Harbour and Cootes Paradise CSO inputs are shown in Table 16 and 17 respectively.

$$L(x) = C(x) * V * 1\ yr/365\ days * 1000\ L/1\ m^3 * 1\ kg/1000000\ mg \qquad \textbf{(equation 1)}$$

where

$L(x)$ = loading per parameter, kg/day
$C(x)$ = average CSO concentration of parameter, mg/L
V = CSO annual volume, m^3/yr

Table 16. Estimated Hamilton Harbour CSO Contaminant Loadings (kg/day)

CSO – Hamilton Harbour	1996	1997	1998	1999	2000	2001	2002
Ammonia	204	109	104	123	146	174	150
TKN	388	208	199	235	278	332	287
Phosphorus	80	43	41	49	57	69	59
Total Suspended Solids	4182	2242	2139	2530	2990	3580	3085
Lead	1.0	0.5	0.5	0.6	0.7	0.9	0.8
Iron	174	93	89	105	125	149	129
Zinc	5.7	3.0	2.9	3.4	4.0	4.8	4.2
Phenolics	no data						
Cyanide	no data						
PAH – Naphthalene	no data						
PAH – Benzo(a)pyrene	no data						

CSO – Hamilton Harbour	2003	2004	2005	2006	2007
Ammonia (NH_3-N)	181	110	317	148	32
TKN	345	211	604	283	61
Total Phosphorus	71	44	125	58	13
Total Suspended Solids	3710	2268	6507	3045	655
Lead	0.9	0.6	1.6	0.7	0.2
Iron	155	95	271	127	27
Zinc	5.0	3.1	8.8	4.1	0.9
Phenolics	no data				
Cyanide	no data				
PAH – Naphthalene	no data				
PAH – Benzo(a)pyrene	no data				

Table 17. Estimated Cootes Paradise CSO Contaminant Loadings (kg/day)

CSO – Cootes Paradise	1996	1997	1998	1999	2000	2001	2002
Ammonia	26.8	15.3	4.3	5.9	3.8	6.9	5.1
TKN	51	29	8	11	7	13	10
Phosphorus	10.6	6.0	1.7	2.3	1.5	2.7	2.0
Total Suspended Solids	551	315	89	121	79	142	105
Lead	0.1	0.1	0.02	0.03	0.02	0.03	0.03
Iron	23	13	4	5	3	6	4
Zinc	0.7	0.4	0.1	0.2	0.1	0.2	0.1
Phenolics	no data						
Cyanide	no data						
PAH – Naphthalene	no data						
PAH – Benzo(a)pyrene	no data						

CSO – Cootes Paradise	2003	2004	2005	2006	2007
Ammonia (NH_3-N)	3.6	14.6	22.7	12.7	0.7
TKN	7	28	43	24	1
Total Phosphorus	1.4	5.8	8.9	5.0	0.3
Total Suspended Solids	74	301	466	260	14
Lead	0.02	0.07	0.11	0.06	0
Iron	3	13	19	11	0.6
Zinc	1.0	0.4	0.6	0.4	0.02
Phenolics	no data				
Cyanide	no data				
PAH – Naphthalene	no data				
PAH – Benzo(a)pyrene	no data				

7.4 Urban Runoff

Urban runoff is a non-point source of pollution produced as rainwater washes off surfaces in urban areas during a storm event. In communities with a separated system, sanitary sewers take sewage to wastewater treatment plants, and storm sewers deliver untreated urban runoff directly into natural water bodies. In the Hamilton Harbour watershed, separated systems are used in Burlington (Aldershot and the Hager-Rambo Creek diversion channel) and parts of Hamilton (including Ancaster, Dundas, Stoney Creek, and Waterdown).

It is difficult to separate the contributions of urban runoff and non-urban creeks. In an attempt to avoid as much double counting as possible in loading totals, urban runoff estimates are subtracted from the creek estimates. As both of these are estimates calculated using different models of varying sophistication, many of the creek loadings result in negative numbers. This does not mean that there has been an actual net decrease in the contaminant, it just highlights the need to improve the methodologies used.

As neither flows nor concentrations are measured in the local storm sewers, estimated loadings from urban runoff entering Hamilton Harbour and Cootes Paradise are calculated using equation 2:

$$L(x) = R * C(x) * 1000\ L/1\ m^3 * 1\ kg/1000000\ mg \qquad \textbf{(equation 2)}$$

where

$L(x)$ = loading per parameter, kg/day
R = average urban runoff volume, m^3/day (See equation 3 below)
$C(x)$ = average concentration of parameter, mg/L

Average urban runoff values (R) for Hamilton Harbour and Cootes Paradise are calculated using equation 3:

$$R = P * (\sum C_j * A_j) * 1\ m/1000\ mm * 1000000\ m^2/1\ km^2 * 1\ year/365\ days \qquad \textbf{(equation 3)}$$

where

R = average urban runoff volume, m^3/day
P = annual precipitation, mm/year
C_j = volumetric runoff coefficient where $_j$ equals land use type
A_j = area where $_j$ equals land use type, km^2
Note: In leap years (1996, 2000) the formula was adjusted to 1 year/366 days

As shown in equation 3, the total loading for an urban area is obtained by adding contributions from individual land use types. The quantity of runoff in an area can depend on population and land use characteristics. Therefore the total urban area is divided into representative land use categories: industrial, open land, commercial, and residential. Each land use has a corresponding volumetric runoff coefficient (C_j) values which “were selected somewhat conservatively to reflect annual volumes of runoff rather than single event conditions.” (Marsalek and Schroeter 1988, p.368) The weighted area for both Hamilton Harbour and Cootes Paradise is shown in Table 18.

Table 18. Area weighted by land use type coefficients

			Hamilton Harbour				Cootes Paradise			
Land Use Type	C_j		A_j (km^2)		C_j*A_j (km^2)		A_j (km^2)		C_j*A_j (km^2)	
• industrial	C_i	0.7	A_i	6.7	C_i*A_i	4.69	A_i	0.5	C_i*A_i	0.35
• open	C_o	0.1	A_o	2.8	C_o*A_o	0.28	A_o	2.5	C_o*A_o	0.25
• commercial	C_c	0.9	A_c	4.4	C_c*A_c	3.96	A_c	3.8	C_c*A_c	3.42
• residential	C_r	0.35	A_r	22.2	C_r*A_r	7.77	A_r	17.8	C_r*A_r	6.23
					$\sum C_j$*A_j	**16.70**			**$\sum C_j$*A_j**	**10.25**

C_j Source: Marsalek + Schroeter 1988, p.368 A_j Source: 1990-1996 Loadings Report, p.34

Environment Canada's station at the Hamilton Airport was selected to represent annual precipitation values (Table 19), as it has been "found by other researchers to be more representative of rainfall patterns in the Hamilton area than the Royal Botanical Gardens rainfall gauge" (Theil and Beak 1991, p. 48).

Table 19. Annual Precipitation, P (mm)

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Annual Precipitation (mm)	1114.8	772.5	677.0	892.5 [1]	930.2	794.4 [2]	783.0

	2003	**2004**	**2005**	**2006**	**2007**
Annual Precipitation (mm)	902.5	951.8	992.9	1033.3	702.2

Source: Canadian Daily Climate Data (http://www.climate.weatheroffice.ec.gc.ca/Welcome_e.html) Station 6153194 YHM

[1] After production of the 1996-2002 report the 1999 precipitation value was changed on the EC website (was 826.1).

[2] After production of the 1996-2002 report the 2001 precipitation value was changed on the EC website (was 797.3).

Average contaminant concentration values, C(x), were obtained from various sources as listed in Table 20. These vary from the 1990-1996 Loadings Report in two cases: ammonia was not reported in the previous report and the old value for lead (0.02 mg/L) could not be confirmed with the limited reference provided. However, as a value for ammonia was found alongside the other contaminants in the "Pollution Control Plan" (1991), this new value was chosen for this report. A lead value of 0.057 mg/L was taken from storm sewer sampling for Toronto Inner Harbour (Maunder 1995). The lead value of 0.14 mg/L in the "Pollution Control Plan" was comparable to the CSO values measured in the Toronto study, indicating that the old Hamilton number may not represent only storm water. The iron concentration does need further explanation. The value 6.12 mg/L first appeared in the 1990-1996 Loadings Report. It appears this value comes from averaging concentrations measured in Sarnia, Sault Ste. Marie, and Windsor (Marsalek and Ng 1989, p 449). For the purposes of this report it was felt since these were all urban areas with heavy industry, it would be suitable to use again for Hamilton Harbour (Marsalek, personal communication, March 2004).

Table 20. Average Urban Runoff Contaminant Concentrations, C(x) (mg/L)

Contaminant	Average Concentration (mg/L)	Source
Ammonia	0.3	Theil + Beak 1991, after pg 53
TKN	1.35	Theil + Beak 1991, after pg 53
TP	0.33	Theil + Beak 1991, after pg 53
TSS	100	Theil + Beak 1991, after pg 53
Pb	0.057	Maunder 1995
Fe	6.12	Marsalek and Ng 1989
Zn	0.16	Theil + Beak 1991, after pg 53

The estimated contaminant loads from urban runoff entering Hamilton Harbour and Cootes Paradise are summarized in the Tables 21 and 22 respectively.

Table 21. Estimated Urban Runoff Contaminant Loadings for Hamilton Harbour(kg/day)

URBAN RUNOFF - HH	1996	1997	1998	1999*	2000	2001*	2002
Ammonia	15.3	10.6	9.3	12.3	12.7	10.9	10.7
TKN	68.7	47.7	41.8	55.1	57.3	49.1	48.4
Total Phosphorus	16.8	11.7	10.2	13.5	14.0	12.0	11.8
Total Suspended Solids	5087	3534	3098	4083	4244	3635	3582
Lead	2.9	2.0	1.8	2.3	2.4	2.1	2.0
Iron	311.3	216.3	189.6	249.9	259.8	222.4	219.2
Zinc	8.1	5.7	5.0	6.5	6.8	5.8	5.7
Phenolics	no data						
Cyanide	no data						
PAH – Naphthalene	no data						
PAH – Benzo(a)pyrene	no data						

URBAN RUNOFF - HH	2003	2004	2005	2006	2007
Ammonia	12.4	13.0	13.6	14.2	9.6
TKN	55.7	58.6	61.3	63.8	43.4
Total Phosphorus	13.6	14.3	15.0	15.6	10.6
Total Suspended Solids	4129	4343	4543	4728	3213
Lead	2.4	2.5	2.6	2.7	1.8
Iron	252.7	265.8	278.0	289.3	196.6
Zinc	6.6	6.9	7.3	7.6	5.1
Phenolics	no data				
Cyanide	no data				
PAH – Naphthalene	no data				
PAH – Benzo(a)pyrene	no data				

* After production of the 1996-2002 report the 1999 and 2001 precipitation values were changed on the EC website, data points have been altered to reflect these changes.

Table 22. Estimated Urban Runoff Contaminant Loadings for Cootes Paradise (kg/day)

URBAN RUNOFF - CP	1996	1997	1998	1999*	2000	2001*	2002
Ammonia	9.4	6.5	5.7	7.5	7.8	6.7	6.6
TKN	42.1	29.3	25.7	33.8	35.2	30.1	29.7
Phosphorus	10.3	7.2	6.3	8.3	8.6	7.4	7.3
Total Suspended Solids	3122	2169	1901	2506	2605	2231	2199
Lead	1.8	1.2	1.1	1.4	1.5	1.3	1.2
Iron	191.1	132.8	116.4	153.4	159.4	136.5	134.6
Zinc	5.0	3.5	3.0	4.0	4.2	3.6	3.5
Phenolics	no data						
Cyanide	no data						
PAH – Naphthalene	no data						
PAH – Benzo(a)pyrene	no data						

URBAN RUNOFF - CP	2003	2004	2005	2006	2007
Ammonia	7.6	8.0	8.4	8.7	5.9
TKN	34.2	36.0	37.6	39.2	26.6
Total Phosphorus	8.4	8.8	9.2	9.6	6.5
Total Suspended Solids	2534	2666	2788	2902	1972
Lead	1.4	1.5	1.6	1.6	1.1
Iron	155.1	163.1	170.6	177.6	120.7
Zinc	4.1	4.3	4.5	4.6	3.2
Phenolics	no data				
Cyanide	no data				
PAH – Naphthalene	no data				
PAH – Benzo(a)pyrene	no data				

* After production of the 1996-2002 report the 1999 and 2001 precipitation values were changed on the EC website, data points have been altered to reflect these changes.

7.5 Creeks

As it would be impractical to attempt to monitor every creek that enters Hamilton Harbour or Cootes Paradise, the three largest creeks are used to calculate a loadings estimate. Grindstone Creek and Red Hill Creek discharge into Hamilton Harbour, while Spencer Creek discharges into Cootes Paradise. Flow rates for Indian Creek, which incorporates the Hager-Rambo Creek Diversion, are now available from the City of Burlington; however, the Technical Team decided not to use the available data for Indian Creek as this revision to the methodology used would not provide significantly different calculations of loadings to the Harbour.

Determining loadings for creeks involves estimates, as it would take enormous resources to measure all flows and corresponding concentrations for the three creeks. In 1993, D.W. Draper & Associates Ltd. prepared the "Hamilton Harbour Tributaries Storm Event Monitoring Study" to provide information on contaminant loadings of tributaries in support of the RAP. The methods used to calculate loadings in this report are referred to as "the Draper Method". A key part of the Draper Method is the concept of cutoff values (Draper 1993, p.24). In very simple terms, instead of calculating a loading for every flow measurement, they are grouped into high and low flows with the cutoff value representing the dividing point between the two. This grouping reduces the number of calculations while still providing a useful loading estimate. The Draper Method used in the 1990-1996 Loadings report has come under some criticism for its large margin of error. Due to changes in the frequency and consistency of creek monitoring with the revival of the Provincial Water Quality Monitoring Network, other estimation methods may be able to provide the RAP with better numbers. However, due to the amount of data available, the old method will still be used for Spencer, Red Hill, and Grindstone Creeks for this report.

It is difficult to separate the contributions of urban runoff and non-urban creeks. In an attempt to avoid as much double counting as possible in loading totals, urban runoff estimates are subtracted from the creek estimates. As both of these are estimates calculated using different models of varying sophistication, many of the creek loadings end up negative numbers. <u>This does not mean that there has been an actual net decrease in the contaminant</u>, it just highlights the need to improve the methodologies used.

7.5.1 Estimated Non-Urban Creek Loadings to Cootes Paradise

Method to calculate flow volumes for Spencer Creek (Table 23):

i) Obtain daily discharge (m^3/sec) data for year.
(Source: Water Survey of Canada, Station 02HB007)

ii) Sort flows in descending order and find cutoff value (5.75 m^3/sec).
(Source: Draper Report, p. 25)

iii) Multiply each flow greater than or equal to (≥) the cutoff value by 86400 sec/day to obtain a daily flow (m^3/day). Sum the daily flows to obtain a total flow volume (m^3).

iv) Repeat step iii for flows less than (<) the cutoff value.

Table 23. Spencer Creek Flow Volumes – Using the 5.75 m^3/sec Cutoff Value

Year	V_a Volume Above Cutoff (millions of m^3)	V_b Volume Below Cutoff (millions of m^3)	# Days Above	# Days Below
1996*	35.07	65.62	45	321
1997	26.54	41.00	32	333
1998	20.19	27.62	28	337
1999	0	28.66	0	365
2000*	17.67	43.29	25	341
2001	5.97	44.78	8	357
2002	2.10	38.02	4	361
2003	18.77	39.30	28	337
2004*	18.51	40.06	23	343
2005	30.10	37.83	37	328
2006	20.05	62.25	29	336
2007	12.15	33.43	16	349

* Leap Year- Water Survey of Canada takes 366 daily sample records in a leap year

Table 24. Spencer Creek Parameter Concentrations - Using the 5.75 m^3/sec Cutoff Value

Parameter	$C(x)_a$ Concentration Above Cutoff (mg/L)	$C(x)_b$ Concentration Below Cutoff (mg/L)
Total Nitrogen *	2.39	1.77
TP *	0.218	0.105
SS *	102.6	25.4
Pb *	0.0061	0.0061
Fe **	3.5	0.38
Zn *	0.0883	0.0151

* Source: Draper Report (p. 25, Table 12)
** Source: 1990-1996 Loadings Report (p. 12 + p. 39) which used Hamilton CA sampling results

Method to calculate loadings for Spencer Creek (Table 25):

i) Calculate annual loading for the parameter above cutoff value.

$L(x)_{yra} = C(x)_a * V_a * 1\ kg/1{,}000{,}000\ mg * 1000\ L/1\ m^3$
where
$L(x)_{yra}$ = annual loading per parameter above cutoff value, kg/year
$C(x)_a$ = parameter concentration above cutoff value, mg/L (Table 24)
V_a = volume above cutoff value, m^3

ii) Calculate annual loading for the parameter below cutoff value. Substitute $L(x)_{yrb}$, $C(x)_b$ and V_b in equation.

iii) Sum both annual loadings. $L(x)_{yr} = L(x)_{yra} + L(x)_{yrb}$

iv) Convert total annual loading into a daily loading (kg/day).
If a regular year: $L(x) = L(x)_{yr} * 1/365$
If a leap year: $L(x) = L(x)_{yr} * 1/366$

v) Multiply the daily loading by a factor of 1.44 in order to account for the influence of other small creeks entering Cootes Paradise (Borer, Chedoke, Ancaster) which are not monitored by the Water Survey of Canada (Source: 1990-1996 Loadings Report, p. 37 + p.39)

Table 25. Estimated Creek Loadings to Cootes Paradise (kg/day)

CREEKS - CP	1996	1997	1998	1999	2000	2001	2002
Total Nitrogen *	787	537	383	200	468	369	285
Phosphorus	57.2	39.8	28.8	11.9	33.0	23.7	17.6
Total Suspended Solids	20716	14852	10940	2872	11460	6903	4658
Lead	2.4	1.6	1.2	0.7	1.5	1.2	1.0
Iron	581	428	320	43	308	150	86
Zinc	16.1	11.7	8.7	1.7	8.7	4.7	3.0

CREEKS - CP	2003	2004	2005	2006	2007
Total Nitrogen *	451	453	548	624	348
Phosphorus	32.4	32.4	41.6	43.0	24.3
Total Suspended Solids	11534	11474	15974	14354	8269
Lead	1.4	1.4	1.6	2.0	1.1
Iron	318	315	472	370	218
Zinc	8.9	8.8	12.7	10.7	6.2

* The Draper Report provides upper and lower stratum concentrations for total nitrogen, not ammonia or TKN. The 1990-1996 Loadings Report used TKN concentrations from the Draper Report, which may be an inconsistency; however Draper's definition of total nitrogen is unclear.

vi) The loading calculated for urban runoff for Cootes Paradise (see Section 7.4 – Table 22) needs to be subtracted from the creek loading (Table 26). This ensures that urban runoff is not counted twice with regards to mass loadings to Cootes Paradise and Hamilton Harbour; however, in some cases this results in a negative value due to the comparison of two estimates.

Table 26. Estimated Non-Urban Creek Loadings to Cootes Paradise (kg/day)

CREEK - CP	1996	1997	1998	1999	2000	2001	2002
Total Nitrogen	not available as urban runoff measures TKN						
Phosphorus	46.9	32.7	22.5	3.6	24.4	16.3	10.3
Total Suspended Solids	17594	12682	9039	366	8855	4672	2459
Lead	0.6	0.4	0.1	-0.7	-0.02	-0.05	-0.3
Iron	390	295	204	-110	149	13	-49
Zinc	11.1	8.2	5.6	-2.3	4.5	1.2	-0.5

CREEK - CP	2003	2004	2005	2006	2007
Total Nitrogen	not available as urban runoff measures TKN				
Phosphorus	24.1	23.6	32.4	33.5	17.8
Total Suspended Solids	9000	8809	13186	11453	6297
Lead	-0.05	-0.1	0.05	0.3	-0.03
Iron	163	152	302	193	97
Zinc	4.8	4.5	8.3	6.1	3.1

7.5.2 Estimated Red Hill Creek Loadings to Hamilton Harbour

The Red Hill Creek is sampled for both flow and concentrations at a location that is above the input of Woodward WWTP effluent.

Method to calculate flow volumes for Red Hill Creek (Table 27):

i) Obtain daily discharge (m^3/sec) data for year.
(Source: Water Survey of Canada, Station 02HA014)

ii) Sort flows in descending order and find cutoff value (4.0 m^3/sec).
(Source: 1990-1996 Loadings Report (p. 12) states this is from the Draper Report, but that report doesn't cover Red Hill)

iii) Multiply each flow greater than or equal to (≥) the cutoff value by 86400 sec/day to obtain a daily flow (m^3/day). Sum the daily flows to obtain a total flow volume (m^3).

iv) Repeat step iii for flows less than (<) the cutoff value.

Table 27. Red Hill Creek Flow Volumes – Using the 4.0 m^3/sec Cutoff Value

Year	V_a Volume Above Cutoff (millions of m^3)	V_b Volume Below Cutoff (millions of m^3)	# Days Above	# Days Below
1996*	13.30	17.75	16	350
1997	3.76	14.93	6	359
1998	8.15	11.99	12	353
1999	4.56	11.98	8	357
2000*	9.07	14.21	17	349
2001	5.39	16.53	8	357
2002	1.53	12.35	4	361
2003**	no data			
2004**	no data			
2005**	no data			
2006**	no data			
2007**	no data			

* Leap Year- Water Survey of Canada takes 366 daily sample records in a leap year
** There is no data available for August 23, 2003-December 31, 2007 as flow equipment was removed during construction in area

Table 28. Red Hill Creek Parameter Concentrations - Using the 4.0 m^3/sec Cutoff Value

Parameter	$C(x)_a$ Concentration Above Cutoff (mg/L)	$C(x)_b$ Concentration Below Cutoff (mg/L)
Total Nitrogen	5.5	0.97
TP	0.5	0.19
SS	350	50
Pb	0.00137	0.0078
Fe	4.4	1.1
Zn	0.094	0.036

Source: 1990-1996 Loadings Report (p. 40) which used 1992 RAP Report and Hamilton CA sampling results

Method to calculate loadings for Red Hill Creek (Table 29):

i) Calculate annual loading for the parameter above cutoff value.

$L(x)_{yra} = C(x)_a * V_a * 1\ kg/1{,}000{,}000\ mg * 1000\ L/1\ m^3$
where
$L(x)_{yra}$ = annual loading per parameter above cutoff value, kg/year
$C(x)_a$ = parameter concentration above cutoff value, mg/L (Table 28)
V_a = volume above cutoff value, m^3

ii) Calculate annual loading for the parameter below cutoff value. Substitute $L(x)_{yrb}$, $C(x)_b$ and V_b in equation.

iii) Sum both annual loadings. $L(x)_{yr} = L(x)_{yra} + L(x)_{yrb}$

iv) Convert total annual loading into a daily loading (kg/day).
If a regular year: $L(x) = L(x)_{yr} * 1/365$
If a leap year: $L(x) = L(x)_{yr} * 1/366$

v) Multiply the daily loading by a factor of 4/3 in order to account for the influence of other small urban creeks entering the Harbour. (Source: 1990-1996 Loadings Report, p. 41)

Table 29. Estimated Red Hill Creek Loadings to Hamilton Harbour (kg/day)

RED HILL CREEK	1996	1997	1998	1999	2000	2001	2002
Total Nitrogen	329	129	206	134	232	167	75
Phosphorus	36.5	17.2	23.2	16.6	26.3	21.3	11.4
Total Suspended Solids	20187	7540	12607	8012	14147	9913	4216
Lead	0.6	0.4	0.4	0.4	0.4	0.5	0.4
Iron	284	121	179	121	202	153	74
Zinc	6.9	3.3	4.4	3.1	5.0	4.0	2.2
Phenolics	no data						
Cyanide	no data						
PAH – Naphthalene	no data						
PAH – Benzo(a)pyrene	no data						

RED HILL CREEK	2003*	2004*	2005*	2006*	2007*
Total Nitrogen	no data				
Phosphorus	no data				
Total Suspended Solids	no data				
Lead	no data				
Iron	no data				
Zinc	no data				
Phenolics	no data				
Cyanide	no data				
PAH – Naphthalene	no data				
PAH – Benzo(a)pyrene	no data				

* There is no data available for 2003-2007 as flow equipment was removed during construction in area

7.5.3 Estimated Grindstone Creek Loadings to Hamilton Harbour

The Grindstone Creek is sampled for both flow and concentrations at a location that is <u>below</u> the Waterdown WWTP. As such, the data provided by the City of Hamilton for the Waterdown WWTP (Table 9) is not used in this report to calculate the total load to the Harbour (Section 8).

In plotting the flow records for Grindstone Creek from highest to lowest flows, Draper revealed three flow strata, leading to the selection of two flow cutoff values (Draper 1993, Table A4-3).

Method to calculate flow volumes for Grindstone Creek (Table 30):

i) Obtain daily discharge (m^3/sec) data for year.
(Source: Water Survey of Canada, Station 02HB012)

ii) Sort flows in descending order and find <u>two</u> cutoff values (2.1 m^3/sec and 6.1 m^3/sec) to create three flow stratum.
(Source: Draper Report, Table A4-3)

iii) Multiply each flow greater than or equal to the higher cutoff value (≥6.1) by 86400 sec/day to obtain a daily flow (m^3/day). Sum the daily flows to obtain a total flow volume (m^3).

iv) Repeat step iii for flows less than the higher cutoff value, but greater than or equal to the lower cutoff value (< 6.1 and ≥ 2.1).

v) Repeat step iii for flows less than the lower cutoff value (< 2.1).

Table 30. Grindstone Creek Flow Volumes – Using the 2.1 and 6.1 m^3/sec Cutoff Values

Year	V_a Volume Above 6.1 Cutoff (millions of m^3)	V_b Volume Between 2.1 and 6.1 Cutoffs (millions of m^3)	V_c Volume Below 2.1 Cutoff (millions of m^3)	# Days Above	# Days Between	# Days Below
1996*	4.44	11.58	22.89	6	45	315
1997	2.02	11.57	16.51	3	44	318
1998	1.66	11.42	10.66	3	42	320
1999	0	0.71	11.22	0	3	362
2000*	3.39	4.67	16.00	5	17	344
2001	0.56	3.26	17.18	1	12	352
2002	0	3.95	14.49	0	15	350
2003	0	9.72	14.35	0	34	331
2004*	0.58	6.25	16.62	1	24	341
2005	1.65	8.87	14.29	3	29	333
2006	2.18	9.32	22.15	3	37	325
2007**	no data					

* Leap Year- Water Survey of Canada takes 366 daily sample records in a leap year
** 2007 was missing 43 days of flow data due to vandalized equipment and follow-up repairs

Table 31. Grindstone Creek Parameter Concentrations - Using the 2.1 and 6.1 m^3/sec Cutoff Values

Parameter	$C(x)_a$ Concentration Above 6.1 Cutoff (mg/L)	$C(x)_b$ Concentration Between 2.1 and 6.1 Cutoffs (mg/L)	$C(x)_c$ Concentration Below 2.1 Cutoff (mg/L)
Total Nitrogen *	5.27	3.25	4.89
TP	1.19	0.3	0.1
SS	517.8	156.4	17.9
Pb	0.0015	0.0023	0.0051
Fe	no data	no data	no data
Zn	0.0148	0.0061	0.0061

Source: Draper Report (Table A4-3)
* The Draper report provides upper and lower stratum concentrations for total nitrogen, not ammonia or TKN.

Method to calculate loadings for Grindstone Creek (Table 32):

i) Calculate annual loading for the parameter above cutoff value.

$L(x)_{yra} = C(x)_a * V_a * 1\ kg/1{,}000{,}000\ mg * 1000\ L/1\ m^3$
where
$L(x)_{yra}$ = annual loading per parameter above cutoff value, kg/year
$C(x)_a$ = parameter concentration above higher cutoff value, mg/L (Table 31)
V_a = volume above cutoff value, m^3

ii) Calculate annual loading for the parameter between cutoff values. Substitute $L(x)_{yrb}$, $C(x)_b$ and V_b in equation.

iii) Calculate annual loading for the parameter below lower cutoff value. Substitute $L(x)_{yrc}$, $C(x)_c$ and V_c in equation.

iv) Sum all three annual loadings. $L(x)_{yr} = L(x)_{yra} + L(x)_{yrb} + L(x)_{yrc}$

v) Convert total annual loading into a daily loading (kg/day).
If a regular year: $L(x) = L(x)_{yr} * 1/365$
If a leap year: $L(x) = L(x)_{yr} * 1/366$

Table 32. Estimated Grindstone Creek Loadings to Hamilton Harbour (kg/day)

GRINDSTONE CREEK	1996	1997	1998	1999	2000	2001	2002
Total Nitrogen	473	353	268	157	304	267	229
Total Phosphorus	30.2	20.6	17.7	3.7	19.2	9.2	7.2
Suspended Solids	12355	8637	7769	854	7576	3038	2403
Lead	0.4	0.3	0.2	0.2	0.3	0.3	0.2
Iron *	865	605	544	60	530	213	168
Zinc	0.8	0.6	0.4	0.2	0.5	0.4	0.3

GRINDSTONE CREEK	2003	2004	2005	2006	2007**
Total Nitrogen	279	286	294	411	no data
Total Phosphorus	11.9	11.6	16.6	20.8	no data
Suspended Solids	4870	4308	6844	8167	no data
Lead	0.3	0.3	0.3	0.4	no data
Iron *	341	302	479	572	no data
Zinc	0.4	0.4	0.5	0.6	no data

* Source: 1990-1996 Loadings Report (p. 40) which obtained an iron loading for Grindstone Creek by multiplying the SS loading by 0.07. Due to the lack of a better reference, this method was repeated.
** 2007 was missing 43 days of data due to equipment repair

7.5.4 Estimated Non-Urban Creek Loading to Hamilton Harbour

To obtain a representative total creek loading into Hamilton Harbour (Table 33), the estimated Red Hill Creek loadings from Table 29 are added to the estimated Grindstone Creek loadings from Table 32. The estimated loading calculated for urban runoff for Hamilton Harbour (see Section 7.4 – Table 21) is subtracted from the total creek loading (Table 34). This ensures that urban runoff is not counted twice with regards to mass loadings to Cootes Paradise and Hamilton Harbour; however, in some cases it results in negative values, since each of the methodologies for the loading estimates are different. This does not mean that there has been an actual net decrease in the contaminant, it just highlights the need to improve the methodologies used.

Table 33. Estimated Creek Loading to Hamilton Harbour (kg/day)

CREEKS - HH	1996	1997	1998	1999	2000	2001	2002
Total Nitrogen	802	482	475	291	536	434	304
Total Phosphorus	66.7	37.9	40.9	20.3	45.5	30.5	18.6
Suspended Solids	32542	16177	20377	8865	21722	12951	6619
Lead	1.0	0.8	0.6	0.5	0.7	0.8	0.6
Iron	1149	725	723	181	733	366	243
Zinc	7.64	3.81	4.81	3.34	5.45	4.39	2.46
Phenolics	no data						
Cyanide	no data						
PAH – Naphthalene	no data						
PAH – Benzo(a)pyrene	no data						

CREEKS - HH	2003*	2004*	2005*	2006*	2007*
Total Nitrogen	no data				
Total Phosphorus	no data				
Suspended Solids	no data				
Lead	no data				
Iron	no data				
Zinc	no data				
Phenolics	no data				
Cyanide	no data				
PAH – Naphthalene	no data				
PAH – Benzo(a)pyrene	no data				

* There is no data available for 2003-2007 as flow equipment was either removed during construction in area or under repair

Table 34. Estimated Non-Urban Creek Loading to Hamilton Harbour (kg/day)

CREEKS - HH	1996	1997	1998	1999	2000	2001	2002
Total Nitrogen	not available as urban runoff measures TKN						
Total Phosphorus	49.9	26.2	30.7	6.8	31.6	18.5	6.8
Suspended Solids	27455	12642	17279	4782	17478	9316	3037
Lead	-1.9	-1.3	-1.2	-1.8	-1.7	-1.3	-1.5
Iron	838	509	533	-69	473	143	23
Zinc	-0.5	-1.8	-0.1	-3.2	-1.3	-1.4	-3.3
Phenolics	no data						
Cyanide	no data						
PAH – Naphthalene	no data						
PAH – Benzo(a)pyrene	no data						

CREEKS - HH	2003*	2004*	2005*	2006*	2007*
Total Nitrogen	not available as urban runoff measures TKN				
Total Phosphorus	no data				
Suspended Solids	no data				
Lead	no data				
Iron	no data				
Zinc	no data				
Phenolics	no data				
Cyanide	no data				
PAH – Naphthalene	no data				
PAH – Benzo(a)pyrene	no data				

* There is no data available for 2003-2007 as flow equipment was either removed during construction in area or under repair

7.6 Cootes Paradise

Contaminants are discharged to Hamilton Harbour from Cootes Paradise. Contaminant loadings are based on the product of estimated flows and measured concentrations.

The flow from Cootes Paradise to Hamilton Harbour was not measured. Therefore, a value was estimated assuming that the flow out of Cootes Paradise was the same as the flow in. The flow entering Cootes (Table 35) was obtained from the sum of the flow from the Dundas WWTP and the creeks. The mean flowrate for Spencer Creek was multiplied by a factor of 1.44 to account for flows from Borer, Chedoke, and Ancaster Creeks, which are not monitored by the Water Survey of Canada (1990-1996 Loadings Report, p. 37).

Table 35. Average Flow into Cootes Paradise

	Annual Mean Flow Spencer Creek * (m^3/sec)	Annual Daily Flow Watershed Creeks ** (m^3/day)	Average Daily Flow Dundas WWTP *** (m^3/day)	**Average Flow into Cootes Paradise (m^3/day)**
1996	3.18	396185	18579	**414765**
1997	2.14	266468	15766	**282234**
1998	1.52	188605	14775	**203380**
1999	0.91	113054	15307	**128360**
2000	1.93	239857	16752	**256609**
2001	1.61	200212	16408	**216620**
2002	1.27	158262	16605	**174866**
2003	1.84	229080	14047	**243126**
2004	1.85	230440	14155	**244595**
2005	2.15	267979	15515	**283494**
2006	2.61	324694	14651	**339345**
2007	1.45	179819	13572	**193391**

* Source: Water Survey of Canada, Station 02HB007
** Source: Calculated – Spencer Creek flow (m^3/sec) x 1.44 x 86400 sec/day
*** Source: City of Hamilton (1996-2002, A. Nuxoll) (2003-2007, A. Khan)
NOTE: Numbers may be slightly different from 1996-2002 report as no longer rounded during calculations

The Royal Botanical Gardens monitors water quality parameters at two stations at various times during the field season. Station 1 is within 200 m of the Fishway, which is located at the west end of the Desjardins Canal. Station 2 is about 1 km away from the Fishway. For the purposes of this report, the data from the two stations were averaged to produce the concentrations for ammonia, TKN, total suspended solids (seston), and average total phosphorus, listed in Table 36.

Table 36. Average Concentration of Parameters in Cootes Paradise (mg/L)

Year	# of Sample Dates	Ammonia	TKN	TSS	TP
1996	8	0.07	2.26	64	0.18
1997	10	0.10	1.11	21	0.09
1998	11	0.04	1.49	41	0.18
1999	7	0.06	1.58	63	0.27
2000	9	0.08	0.94	38	0.13
2001	11	0.07	1.78	59	0.21
2002	10	0.06	1.54	57	0.15
2003	10	0.03	1.41	44	0.17
2004	10	0.06	1.62	51	0.15
2005	11	0.03	1.59	55	0.20
2006	11	0.05	1.60	50	0.15
2007	11	0.04	1.82	62	0.23

Source: RBG – Average of Station 1 (200m from Fishway) and Station 2 (1km from Fishway)

The average estimated flows into Cootes Paradise (Table 35) are multiplied by the average concentrations (Table 36) to produce loadings estimates (Table 37).

Table 37. Estimated Cootes Paradise Contaminant Loadings to Hamilton Harbour (kg/day)

COOTES PARADISE	1996	1997	1998	1999	2000	2001	2002
Ammonia	29.8	28.2	7.7	7.7	21.4	14.1	9.6
TKN	938	312.86	304	202	241	386	268
Phosphorus	76.4	26.0	36.4	35.2	33.2	45.5	25.9
Total Suspended Solids	26493	5892	8294	8076	9687	12737	10015
Lead	no data						
Iron	no data						
Zinc	no data						
Phenolics	no data						
Cyanide	no data						
PAH – Naphthalene	no data						
PAH – Benzo(a)pyrene	no data						

COOTES PARADISE	2003	2004	2005	2006	2007
Ammonia	6.8	15.7	7.2	17.0	7.0
TKN	342	395	450	543	352
Total Phosphorus	42.3	36.6	56.3	51.4	43.7
Total Suspended Solids	10809	12450	15569	16836	11917

NOTE: Numbers may be slightly different from 1996-2002 report as no longer rounded during calculations

Comments

- Concentration data for lead, iron, zinc, phenolics, and cyanide need to be obtained by reinstating the historical sampling regimes (i.e. 6 times per year) at OMOE Station CP-2A in Cootes Paradise. This station corresponds with RBG Station # 2. Using a historical station would allow greater confidence in looking at long term trends.

- The factor used to account for flows from Borer, Chedoke, and Ancaster Creeks (1.44) came into question during the production of this report. Tÿs Theÿsmeÿer of the RBG suggests that Spencer Creek accounts for 80% of the Cootes Paradise watershed, so 1.25 might be a more appropriate factor.

- A Cootes Paradise Phosphorus Loadings Model is being developed and the report should be released in 2010. This may be a tool that will be useful in the future production of this report.

- Tÿs Theÿsmeÿer of the RBG presented a concern about assuming the flow into Cootes Paradise equals the flow into the Harbour. He felt that this underestimates what is going into the Harbour due to issues such as lake seiche effects, and concentration changes due to mixing of Cootes and Harbour waters. As this report is not intended to be an exact representation of loadings, this issue, although important, cannot possibly be dealt with in the context of this report.

- The 1990-1996 Loadings Report appears to contain a mathematical error in the Cootes Paradise section of Attachment # 2 (p 38). The calculation of the total flow into Cootes Paradise in 1996 should be 414,765 m^3/day instead of 387,600 m^3/day. This error has been carried through all of the loadings estimates for Cootes Paradise in 1996 in that report. This needs to be kept in mind when looking at the old report.

7.7 Ambient Monitoring

Contaminant levels in Hamilton Harbour are measured through ambient monitoring. It is this type of monitoring that will show if Hamilton Harbour has been able to meet the water quality goals set out in Table 1 (p. 3), repeated here for convenience.

	Harbour Initial Goal	Harbour Final Goal	Cootes Paradise	Grindstone Creek Area	Beaches
Phosphorus concentration (µg/L)	34	17	60-70	60-70	
Un-ionized Ammonia concentration (mg/L)	<0.02	<0.02	<0.02	<0.02	
Chlorophyll a concentration (µg/L)	15-20	5-10	20	20	
Secchi Disk Transparency (m)	2	3	1.5	1	1.2
Minimum DO concentration (ppm)	>1	>4	>5	>5	
Submergent/emergent aquatic plant area (ha)	105	170	240	50	
Suspended Solids (ppm)			25	25	
Bacteria (E. coli organisms/ 100 mL water)					<100

Source: Stage 2 Update 2002 (pg. 27, Delisting Objective viii)

Ontario Ministry of the Environment (OMOE) monitors Hamilton Harbour on a three year cycle. In a sampling year, samples are collected three times per year (spring, summer, fall). OMOE has three established stations in Hamilton Harbour: 258 – centre of Harbour, 252 – north east corner of Harbour, 270 – west end of Harbour. Table 38 presents the data collected between 1992 and 2007.

Table 38. OMOE Annual Median Concentrations

Station	Year	TKN (mg/L)	TP (µg/L)	TSS (ppm)	Lead (mg/L)	Iron (mg/L)	Zinc (mg/L)
258	1992	1.580	45	4.0	<0.005	0.090	0.0070
	1994	0.860	37	4.3	<0.005	0.060	0.0058
	1997	0.960	32	3.0	0.0007	0.095	0.0066
	2000	0.730	32	2.5	0.0003	0.023	0.0050
	2003	0.800	31	2.8	0.0003	0.040	0.0066
	2006	0.720	33	5.4	0.0004	0.040	0.0051
	2007	no data		4.4	no data		
252	1992	1.575	58	5.2	<0.005	0.135	0.0070
	1997	1.100	36	3.5	0.0006	0.100	0.0068
	2000	0.920	32	2.0	0.0003	0.067	0.0061
270	1992	1.540	47	4.1	<0.005	0.093	0.0060
	2000	1.040	32	4.0	0.0003	0.065	0.0047

Environment Canada researchers at the National Water Research Institute (NWRI) monitor the required environmental conditions at the centre station (EC Station 52) weekly from May to October (Figures 2 – 5). Although weekly sampling is recommended at only one location, periodically Hamilton Harbour is targeted for intense monitoring where conditions are monitored at 23 more stations Harbour-wide to confirm representativeness of the centre station.

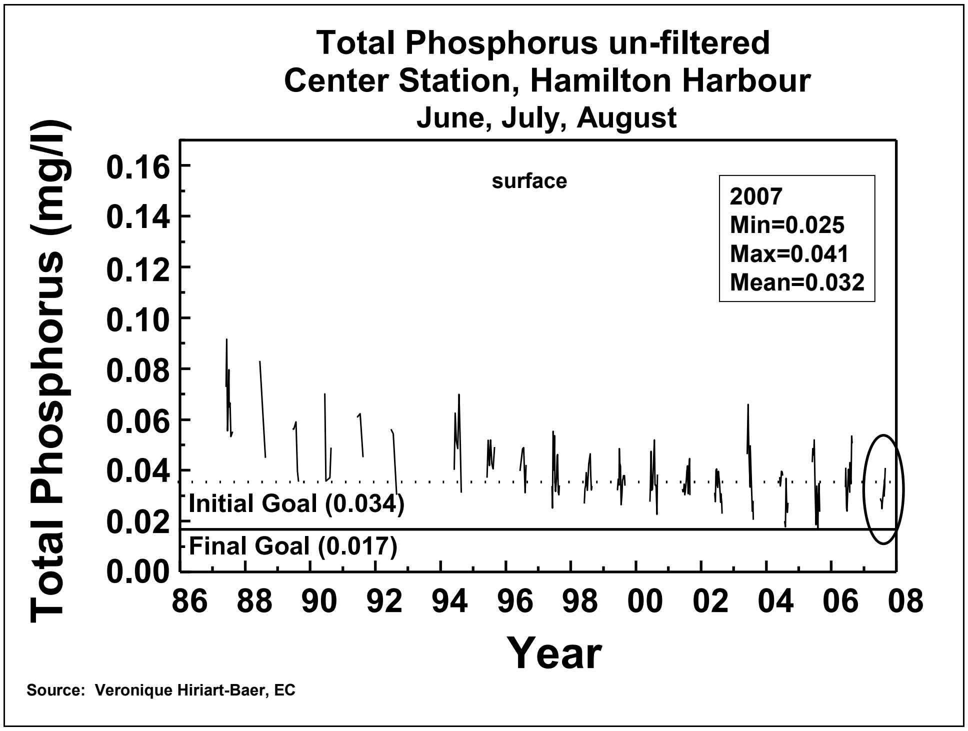

Figure 2. Total Phosphorus (un-filtered) Concentrations at Centre Station (EC)

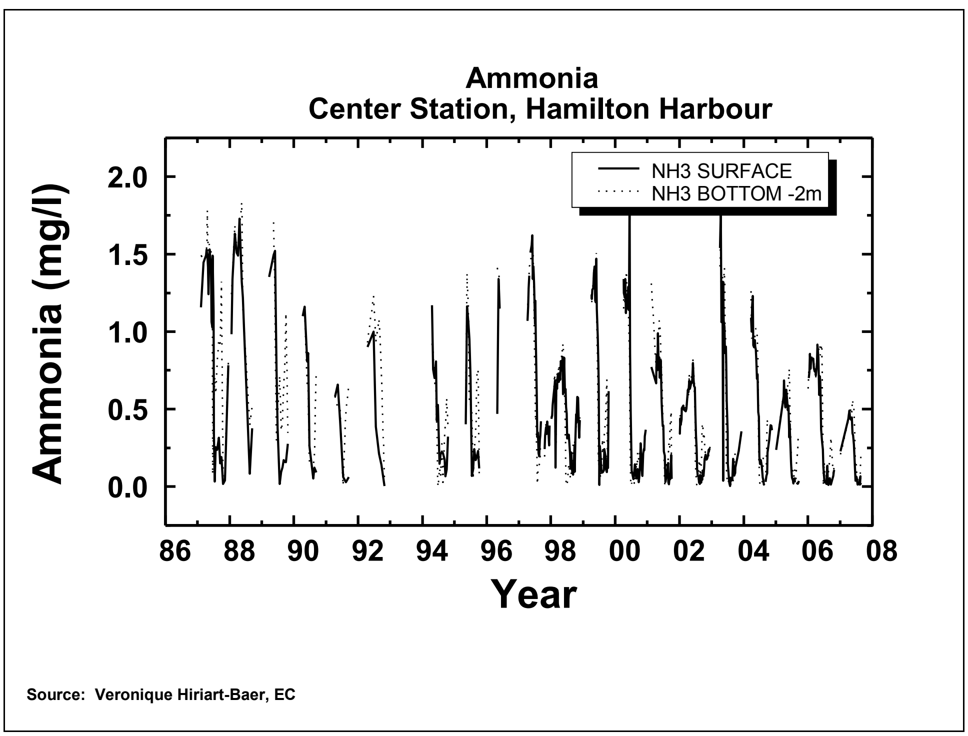

Figure 3. Ammonia Concentrations at Centre Station (EC)

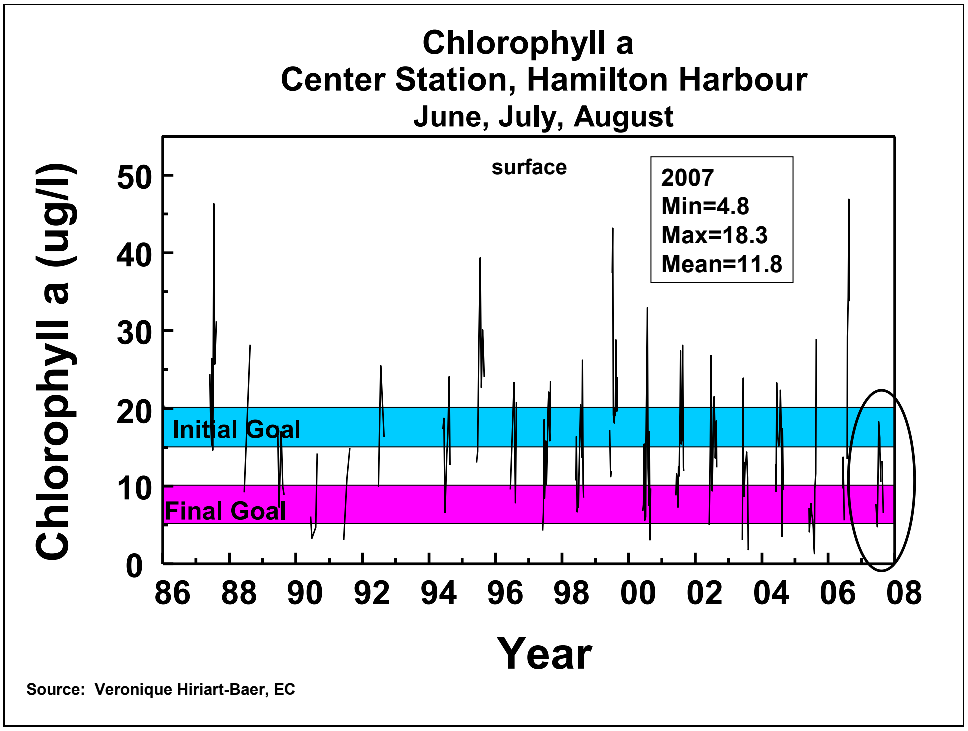

Figure 4. Chlorophyll a Concentrations at Centre Station (EC)

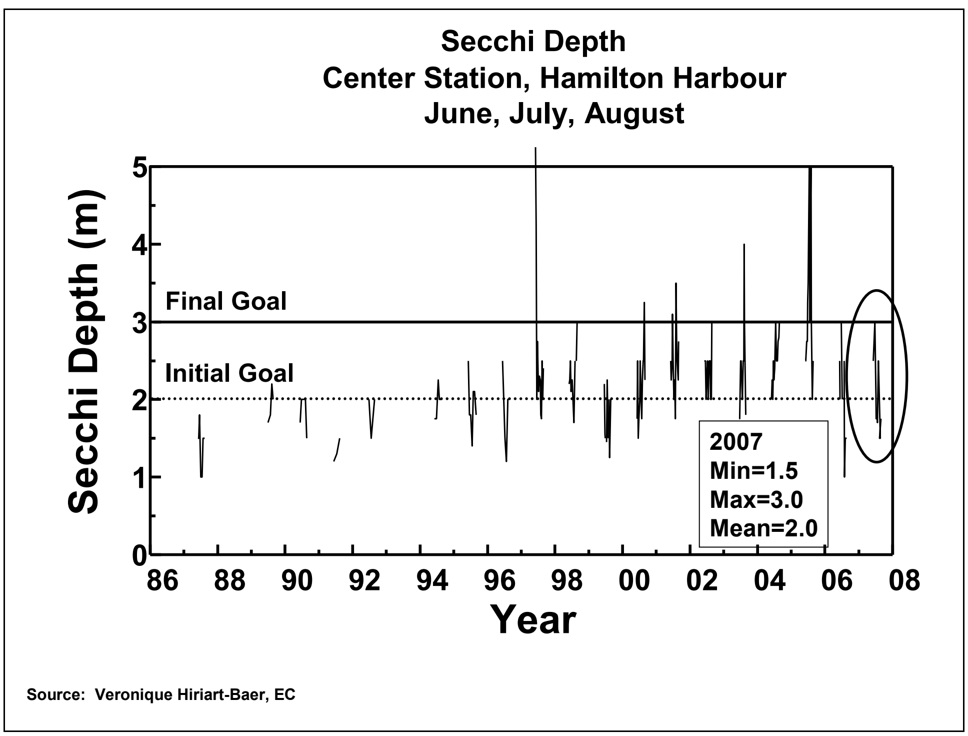

Figure 5. Secchi Depth at Centre Station (EC)

8. Contaminant Summaries

This section presents the same data shown in Section 7, but instead of by source, the loadings are grouped by the contaminants of concern. As both actual and estimated loadings are used to try to provide a “total loading” to Hamilton Harbour and Cootes Paradise, readers need to keep in mind this total is in itself only an estimate. The direct comparison between actual and estimated loadings is artificial, but it is done to give a sense of the big picture.

No attempt was made to interpret the results, and consequently, comments are not provided in this section as to the significance of loading sources or changes in trend. The focus of this report was to present the loading data and estimates for the period 1996-2007. The intention is for the RAP Technical Team to analyse various sections, topics to vary from year to year, and to produce supplementary reports providing their interpretation.

Readers may notice that loadings for Cootes Paradise appear twice for many contaminants. The estimated Cootes Paradise values presented in Section 7.6 are used for the Hamilton Harbour loadings tables and figures. The Cootes Paradise loadings tables and figures use the data (both actual and estimated) from the individual sources listed. The numbers are derived in two different ways; therefore, it is to be expected the two values will not match. This is another downfall of using estimated numbers instead of all actual numbers.

NOTE: Due to extenuating circumstances (flow gauges removed for construction or due to vandalism) there is no data to show for the non-urban creek loading to Hamilton Harbour for 2003-2007 on any of the following graphs. This omission is unfortunate, but discussions around how to calculate an appropriate substitute value concluded stating “no data” was the appropriate course of action.

8.1 Ammonia

Nitrogen can be found in many forms: inorganic nitrogen [ammonia (NH_3), nitrite (NO_2^-), nitrate (NO_3^+), and ammonium (NH_4^+)], and organic nitrogen. Each has its own characteristics and reason for being tracked, leading to various combinations. Total Kjeldahl Nitrogen (TKN) is the sum of ammonia and organic nitrogen. Total Nitrogen is the sum of all nitrogen forms in the water (organic + ammonia + nitrite + nitrate), including those that are not immediately available for biological uptake. Ammonia has been found to be toxic to fish. Steel mills do not produce organic nitrogen, so they track strictly ammonia. Ammonia is not considered a problem in the creek systems, so total nitrogen or TKN is measured. This has made it difficult to create a clear picture of total loading of ammonia into the system. The following tables and figures only show the known ammonia picture.

Table 39. Estimated Ammonia Loadings to Hamilton Harbour (kg/day)

AMMONIA	1996	1997	1998	1999	2000	2001	2002
Woodward WWTP	3962	4229	3857	4517	3943	2925	3175
CSO - HH	204	109	104	123	146	174	150
Skyway WWTP	720	878	508	58	60	133	179
ArcelorMittal Dofasco	356	333	155	152	94	54	34
U. S. Steel Canada *	76	-11	-13	-36	-27	4	-29
Urban Runoff - HH	15	11	9	11	13	11	11
Creeks - HH	no data – measured as total nitrogen						
Cootes Paradise	29	28	8	8	21	15	11
TOTAL	**5362**	**5577**	**4628**	**4832**	**4249**	**3316**	**3531**

AMMONIA	2003	2004	2005	2006	2007
Woodward WWTP	2874	3289	2752	2062	1680
CSO - HH	181	110	317	148	32
Skyway WWTP	195	92	64	31	27
ArcelorMittal Dofasco *	-118	53	46	89	202
U. S. Steel Canada *	-64	-17	13	29	31
Urban Runoff - HH	12	13	14	14	10
Creeks - HH	no data – measured as total nitrogen				
Cootes Paradise	7	16	7	17	7
TOTAL	**3087**	**3556**	**3213**	**2391**	**1988**

* As industries report net data instead of gross, a negative loading indicates the removal of more contaminant from the intake water than is put back through the effluent stream.

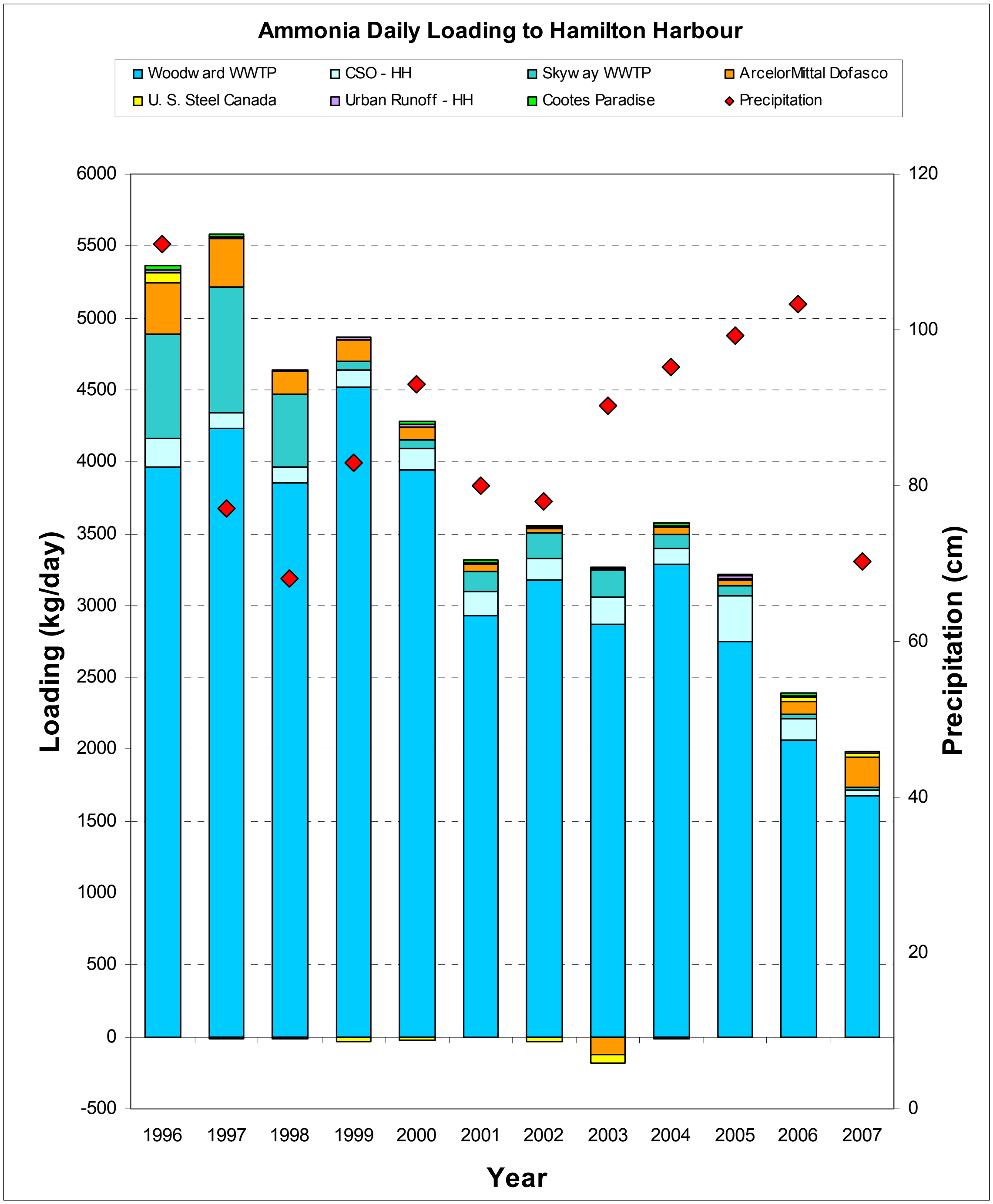

Figure 6: Ammonia Daily Loading to Hamilton Harbour

Table 40. Estimated Ammonia Loadings to Cootes Paradise (kg/day)

AMMONIA	1996	1997	1998	1999	2000	2001	2002
Dundas WWTP	5	5	3	10	6	14	13
CSO - CP	27	15	4	6	4	7	5
Urban Runoff	9	7	6	8	8	7	7
Creeks - CP	no data – measured as total nitrogen						
TOTAL	**41**	**27**	**13**	**23**	**18**	**27**	**25**

AMMONIA	2003	2004	2005	2006	2007
Dundas WWTP	6	1	2	8	6
CSO - CP	4	15	23	13	1
Urban Runoff	8	8	8	9	6
Creeks - CP	no data – measured as total nitrogen				
TOTAL	**17**	**24**	**33**	**30**	**13**

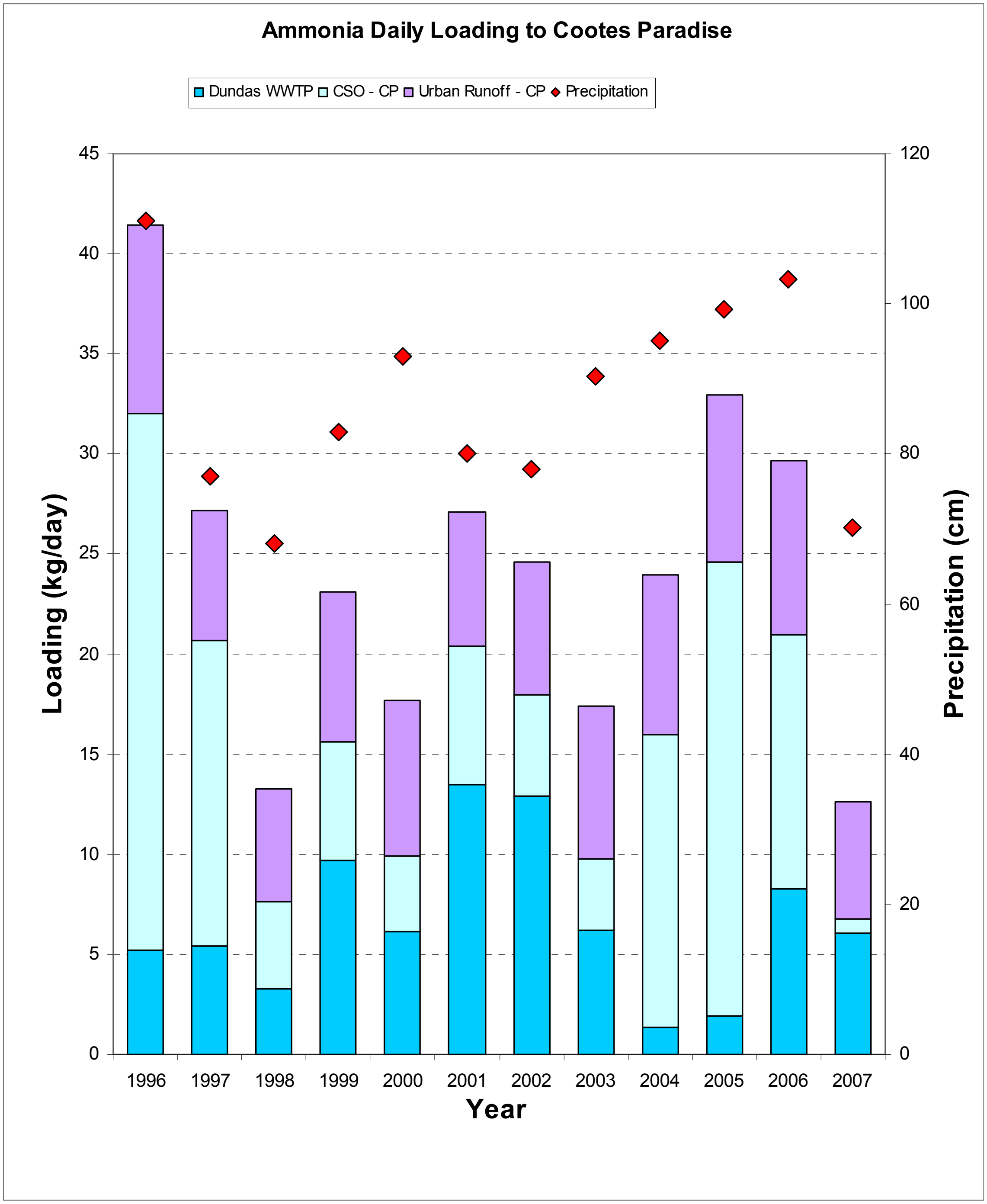

Figure 7: Ammonia Daily Loading to Cootes Paradise

8.2 Total Phosphorous (TP)

Table 41. Estimated Total Phosphorus Loadings to Hamilton Harbour (kg/day)

PHOSPHORUS	1996	1997	1998	1999	2000	2001	2002
Woodward WWTP	143	160	169	166	261	239	198
CSO - HH	80	43	41	49	57	69	59
Skyway WWTP	48	24	20	18	19	15	17
ArcelorMittal Dofasco *	10	-1	10	-7	3	-8	-9
U. S. Steel Canada *	36	9	18	8	1	-3	-7
Urban Runoff - HH	17	12	10	13	14	12	12
Creeks - HH	50	26	31	8	32	19	7
Cootes Paradise	75	25	37	35	33	46	26
TOTAL	**459**	**298**	**335**	**288**	**420**	**388**	**303**

PHOSPHORUS	2003	2004	2005	2006	2007
Woodward WWTP	165	217	239	176	143
CSO - HH	71	44	125	58	13
Skyway WWTP	13	8	11	12	20
ArcelorMittal Dofasco *	8	20	14	-13	9
U. S. Steel Canada *	-4	2	3	6	3
Urban Runoff - HH	14	14	15	16	11
Creeks - HH	no data – flow gauges not available				
Cootes Paradise	42	37	56	51	44
TOTAL	**310**	**342**	**463**	**307**	**242**

* As industries report net data instead of gross, a negative loading indicates the removal of more contaminant from the intake water than is put back through the effluent stream.

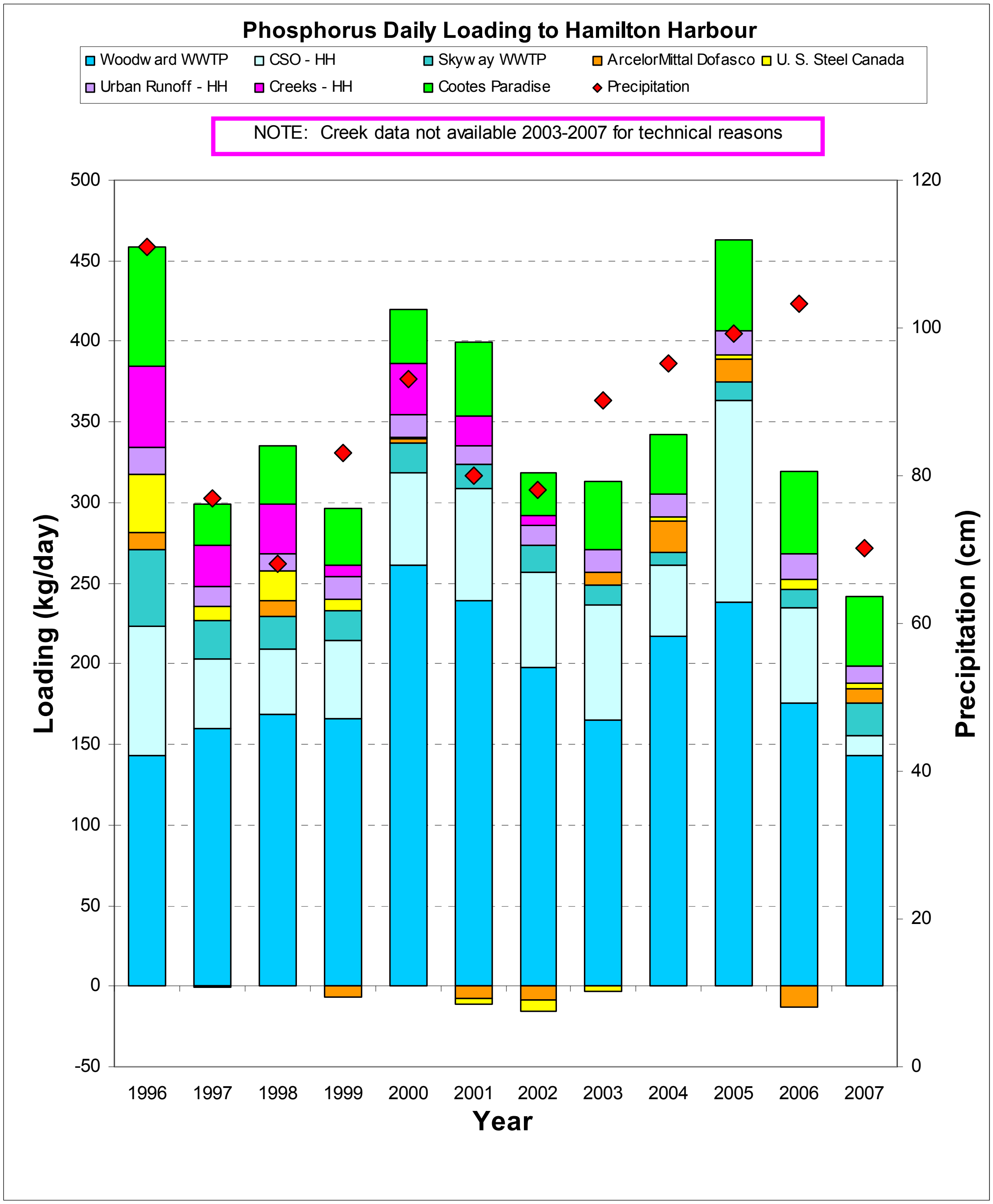

Figure 8: Phosphorus Daily Loading to Hamilton Harbour

Table 42. Estimated Total Phosphorous Loadings to Cootes Paradise (kg/day)

PHOSPHORUS	1996	1997	1998	1999	2000	2001	2002
Dundas WWTP	6	4	5	7	6	5	4
CSO - CP	11	6	2	2	2	3	2
Urban Runoff - CP	10	7	6	8	9	7	7
Creeks - CP	47	33	23	4	24	16	10
TOTAL	**74**	**50**	**36**	**21**	**40**	**31**	**23**

PHOSPHORUS	2003	2004	2005	2006	2007
Dundas WWTP	3	3	4	4	4
CSO - CP	1	6	9	5	0
Urban Runoff - CP	8	9	9	10	7
Creeks - CP	24	24	32	34	18
TOTAL	**37**	**41**	**54**	**52**	**28**

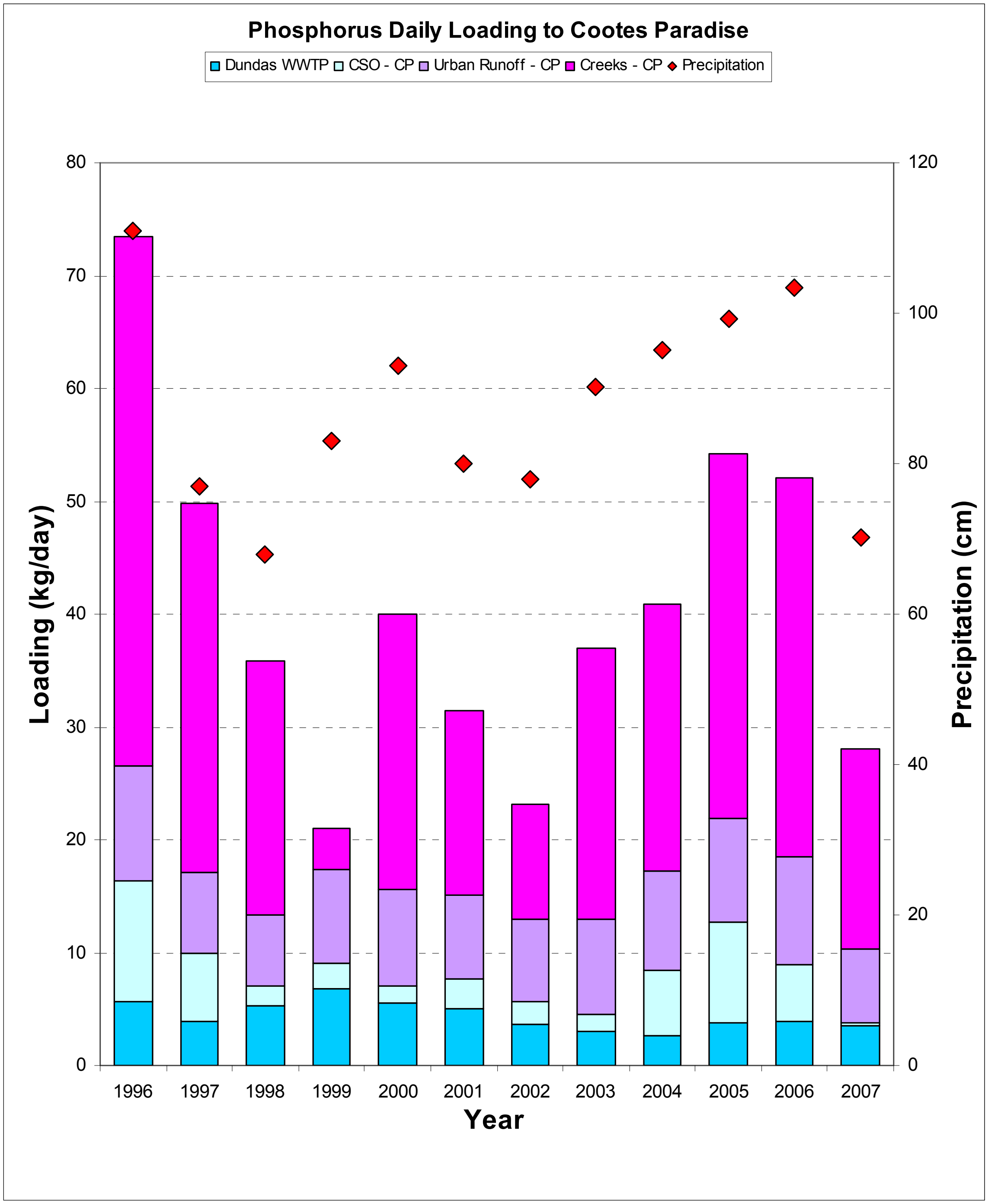

Figure 9: Phosphorus Daily Loading to Cootes Paradise

8.3 Total Suspended Solids (TSS)

Table 43. Estimated Total Suspended Solids Loadings to Hamilton Harbour (kg/day)

SUSPENDED SOLIDS	1996	1997	1998	1999	2000	2001	2002
Woodward WWTP	5751	6939	7036	6580	8312	8443	6567
CSO - HH	4182	2242	2139	2530	2990	3580	3085
Skyway WWTP	549	524	435	554	714	527	461
ArcelorMittal Dofasco	1626	2191	890	1168	1069	812	823
U. S. Steel Canada *	6820	2658	4175	849	314	293	-1228
Urban Runoff - HH	5087	3534	3098	3780	4244	3648	3582
Creeks - HH	27455	12643	17278	5086	17479	9303	3037
Cootes Paradise	26461	5888	8315	8079	9697	12743	10071
TOTAL	**77931**	**36619**	**43366**	**28626**	**44819**	**39349**	**26398**

SUSPENDED SOLIDS	2003	2004	2005	2006	2007
Woodward WWTP	5744	7766	7252	4726	3336
CSO - HH	3710	2268	6507	3045	655
Skyway WWTP	567	293	393	373	420
ArcelorMittal Dofasco	840	1187	1857	1135	1648
U. S. Steel Canada *	-605	-532	762	32	-736
Urban Runoff - HH	4129	4343	4543	4728	3213
Creeks - HH	no data – flow gauges not available				
Cootes Paradise	10809	12450	15569	16836	11917
TOTAL	**25194**	**27775**	**36882**	**30875**	**20454**

* As industries report net data instead of gross, a negative loading indicates the removal of more contaminant from the intake water than is put back through the effluent stream.

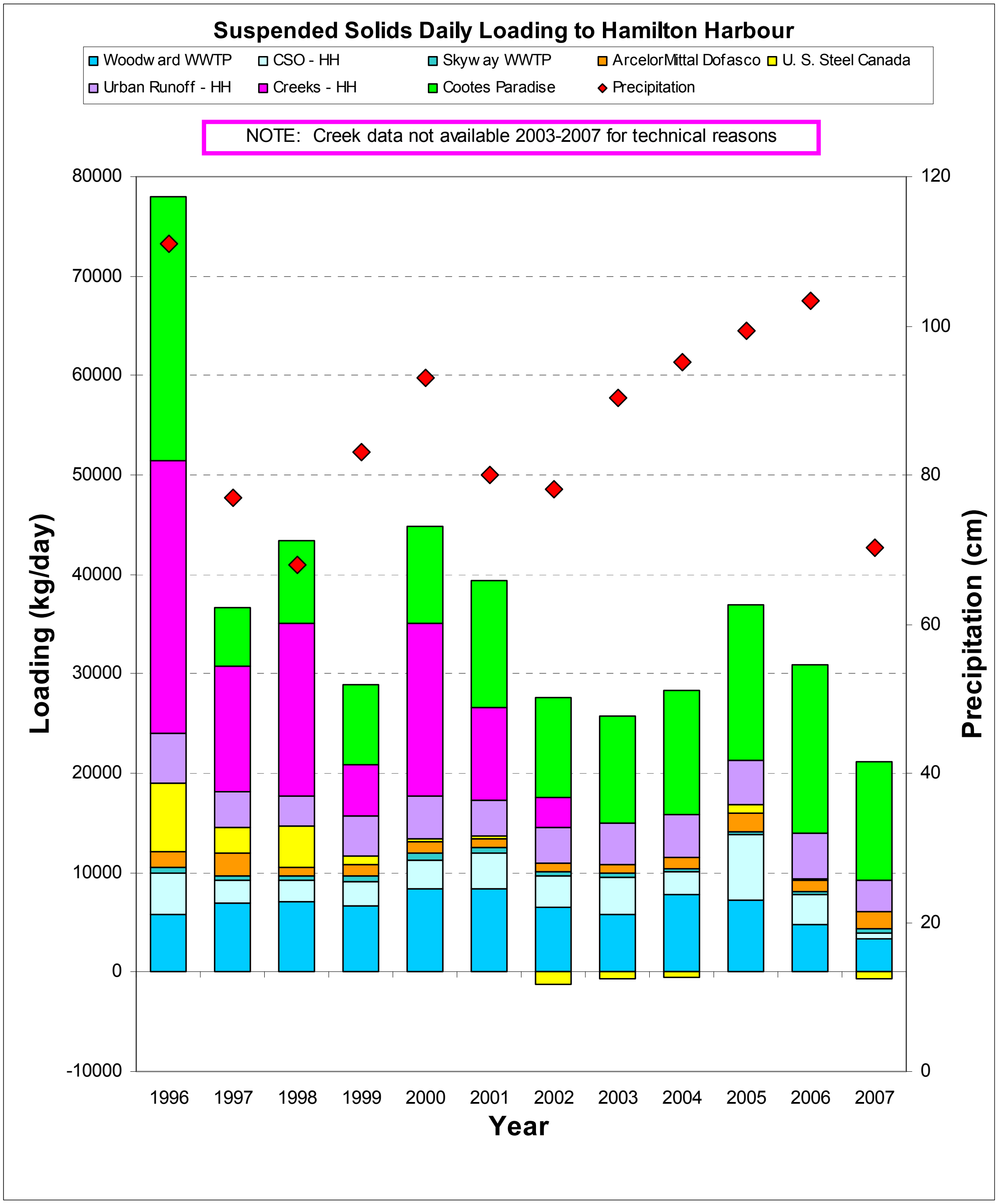

Figure 10. Suspended Solids Daily Loading to Hamilton Harbour

Table 44. Estimated Total Suspended Solids Loadings to Cootes Paradise (kg/day)

SUSPENDED SOLIDS	1996	1997	1998	1999	2000	2001	2002
Dundas WWTP	35	22	24	18	34	35	28
CSO - CP	551	315	89	121	79	142	105
Urban Runoff - CP	3122	2169	1901	2320	2605	2239	2199
Creeks - CP	17594	12682	9039	552	8855	4664	2459
TOTAL	**21302**	**15188**	**11053**	**3011**	**11573**	**7080**	**4791**

SUSPENDED SOLIDS	2003	2004	2005	2006	2007
Dundas WWTP	18	13	14	18	14
CSO - CP	74	301	466	260	14
Urban Runoff - CP	2534	2666	2788	2902	1972
Creeks - CP	9000	8806	13186	11453	6297
TOTAL	**11626**	**11786**	**16454**	**14633**	**8297**

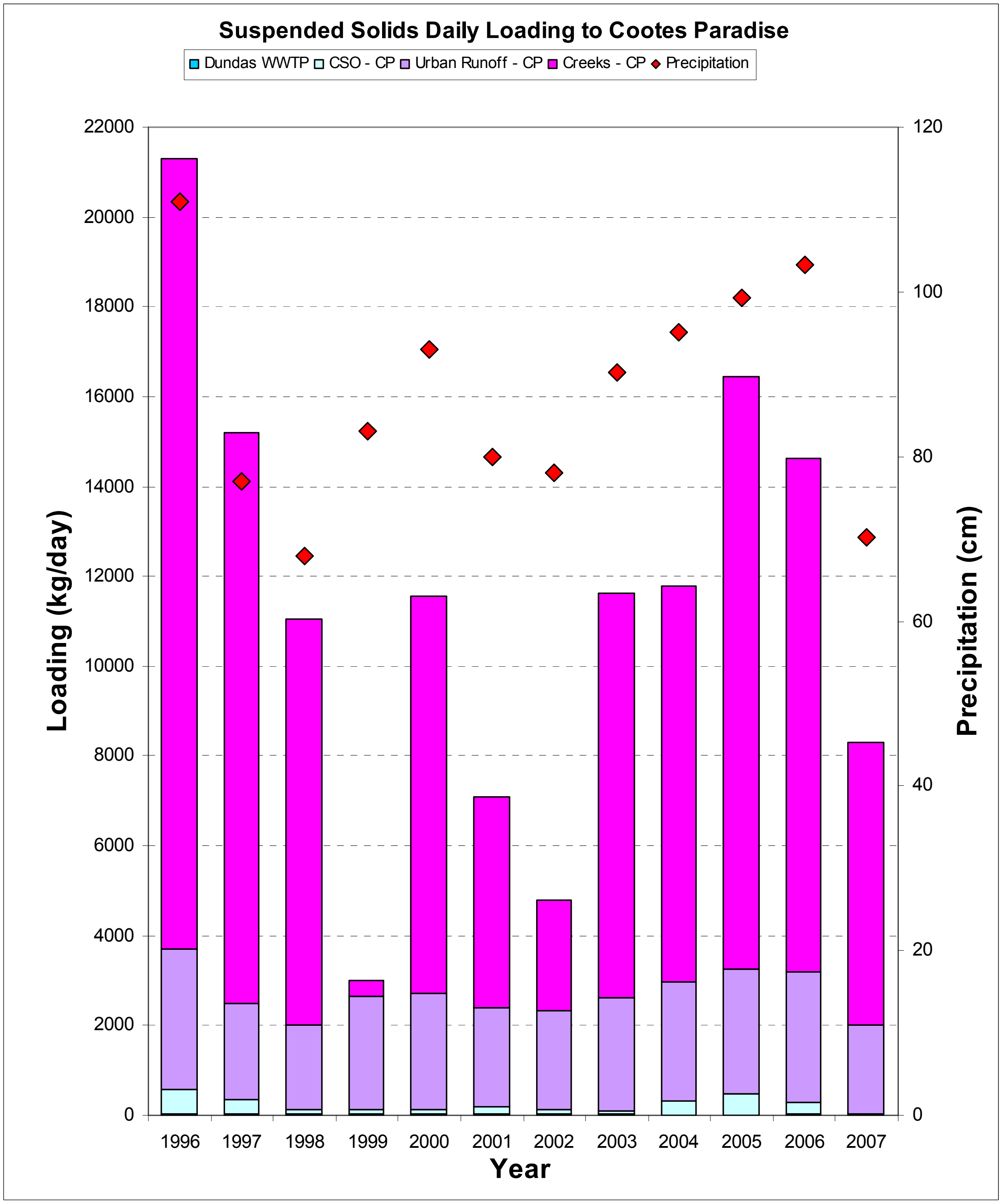

Figure 11. Suspended Solids Daily Loading to Cootes Paradise

8.4 Lead (Pb)

Figures for lead have not been shown as there is not enough data to clearly represent the picture for the whole Harbour. As at least some of the samples in each year were recorded as below the method detection limit (MDL), it was not possible to calculate an accurate loading.

Table 45. Estimated Lead Loadings to Hamilton Harbour (kg/day)

LEAD	1996	1997	1998	1999	2000	2001	2002
Woodward WWTP	27.1	34.1	< MDL	14.5	6.9	< MDL	< MDL
CSO - HH	1.0	0.5	0.5	0.6	0.7	0.9	0.8
Skyway WWTP	< MDL	0.1	< MDL				
ArcelorMittal Dofasco *	-0.2	0.8	0.1	0.1	0.4	0.2	0.4
U. S. Steel Canada *	3.6	-1.0	0.2	0.0	0.4	-0.3	0.2
Urban Runoff - HH	2.9	2.0	1.8	2.2	2.4	2.1	2.0
Creeks – HH **	-1.9	-1.3	-1.2	-1.6	-1.7	-1.3	-1.5
Cootes Paradise	no data						
TOTAL	**32.5**	**35.3**	**1.4**	**15.8**	**9.2**	**1.6**	**2.0**

LEAD	2003	2004	2005	2006	2007
Woodward WWTP	1.3	1.8	1.1	< MDL	0.3
CSO - HH	0.9	0.6	1.6	0.7	0.2
Skyway WWTP	< MDL				
ArcelorMittal Dofasco	0.6	0.6	1.6	1.5	4.0
U. S. Steel Canada	0.0	0.0	0.1	0.1	0.0
Urban Runoff - HH	2.35	2.48	2.59	2.69	1.83
Creeks - HH	no data – flow gauges not available				
Cootes Paradise	no data				
TOTAL	**5.1**	**5.4**	**7.0**	**5.0**	**6.3**

< MDL = concentrations were less than the method detection limit used

* As industries report net data instead of gross, a negative loading indicates the removal of more contaminant from the intake water than is put back through the effluent stream.

** As two different estimates are used to calculate creek loadings, a negative loading indicates the need to improve the methodology used <u>not</u> an actual net decrease in the contaminant.

Table 46. Estimated Lead Loadings to Cootes Paradise (kg/day)

LEAD	1996	1997	1998	1999	2000	2001	2002
Dundas WWTP	1.27	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
CSO - CP	0.1	0.1	0.02	0.03	0.02	0.03	0.03
Urban Runoff - CP	1.8	1.2	1.1	1.3	1.5	1.3	1.3
Creeks – CP *	0.6	0.4	0.07	-0.6	-0.02	-0.06	-0.3
TOTAL	**3.8**	**1.7**	**1.2**	**0.7**	**1.5**	**1.2**	**1.0**

LEAD	2003	2004	2005	2006	2007
Dundas WWTP	no data				
CSO - CP	0.02	0.07	0.11	0.06	0
Urban Runoff - CP	1.4	1.5	1.6	1.7	1.1
Creeks – CP *	-0.05	-0.11	0.05	0.33	-0.03
TOTAL	**1.4**	**1.5**	**1.8**	**2.0**	**1.1**

< MDL = concentrations were less than the method detection limit used

* As two different estimates are used to calculate creek loadings, a negative loading indicates the need to improve the methodology used not an actual net decrease in the contaminant.

8.5 Iron (Fe)

Table 47. Estimated Iron Loadings to Hamilton Harbour (kg/day)

IRON	1996	1997	1998	1999	2000	2001	2002
Woodward WWTP	472	483	1226	580	527	553	500
CSO - HH	174	93	89	105	125	149	129
Skyway WWTP	no data	50	66	98	156	53	135
ArcelorMittal Dofasco	540	371	70	96	119	86	61
U. S. Steel Canada *	no data	no data	134	87	17	2	-20
Urban Runoff - HH	311	216	190	231	260	223	219
Creeks - HH	838	510	533	-50	472	143	23
Cootes Paradise	no data						
TOTAL	**2336**	**1724**	**2308**	**1147**	**1676**	**1209**	**1048**

IRON	2003	2004	2005	2006	2007
Woodward WWTP	339	690	357	279	195
CSO - HH	155	95	271	127	27
Skyway WWTP	65	53	56	48	57
ArcelorMittal Dofasco	79	201	200	7	581
U. S. Steel Canada	24	79	138	93	90
Urban Runoff - HH	253	266	278	289	197
Creeks - HH	no data – flow gauges not available				
Cootes Paradise	no data				
TOTAL	**914**	**1383**	**1300**	**844**	**1146**

* As industries report net data instead of gross, a negative loading indicates the removal of more contaminant from the intake water than is put back through the effluent stream.

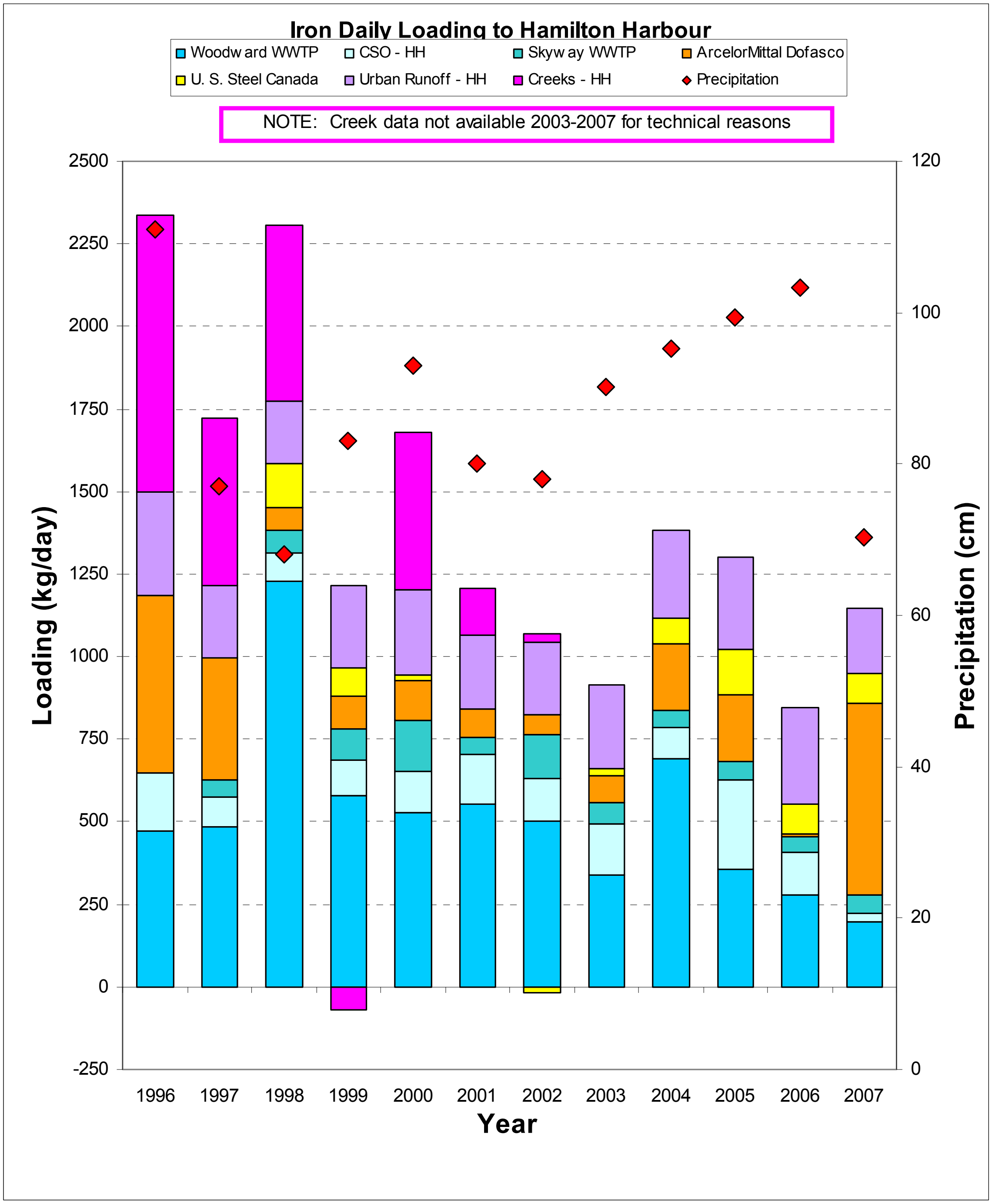

Figure 12. Iron Daily Loading to Hamilton Harbour

Table 48. Estimated Iron Loadings to Cootes Paradise (kg/day)

IRON	1996	1997	1998	1999	2000	2001	2002
Dundas WWTP	4	4	2	9	7	6	4
CSO - CP	23	13	4	5	3	6	4
Urban Runoff - CP	191	133	116	142	159	137	135
Creeks – CP *	390	295	204	-99	149	13	-49
TOTAL	**608**	**445**	**327**	**57**	**318**	**162**	**94**

IRON	2003	2004	2005	2006	2007
Dundas WWTP	no data				
CSO - CP	3	13	19	11	0.6
Urban Runoff - CP	155	163	171	178	121
Creeks - CP	163	152	302	193	97
TOTAL	**321**	**327**	**492**	**381**	**219**

* As two different estimates are used to calculate creek loadings, a negative loading indicates the need to improve the methodology used not an actual net decrease in the contaminant.

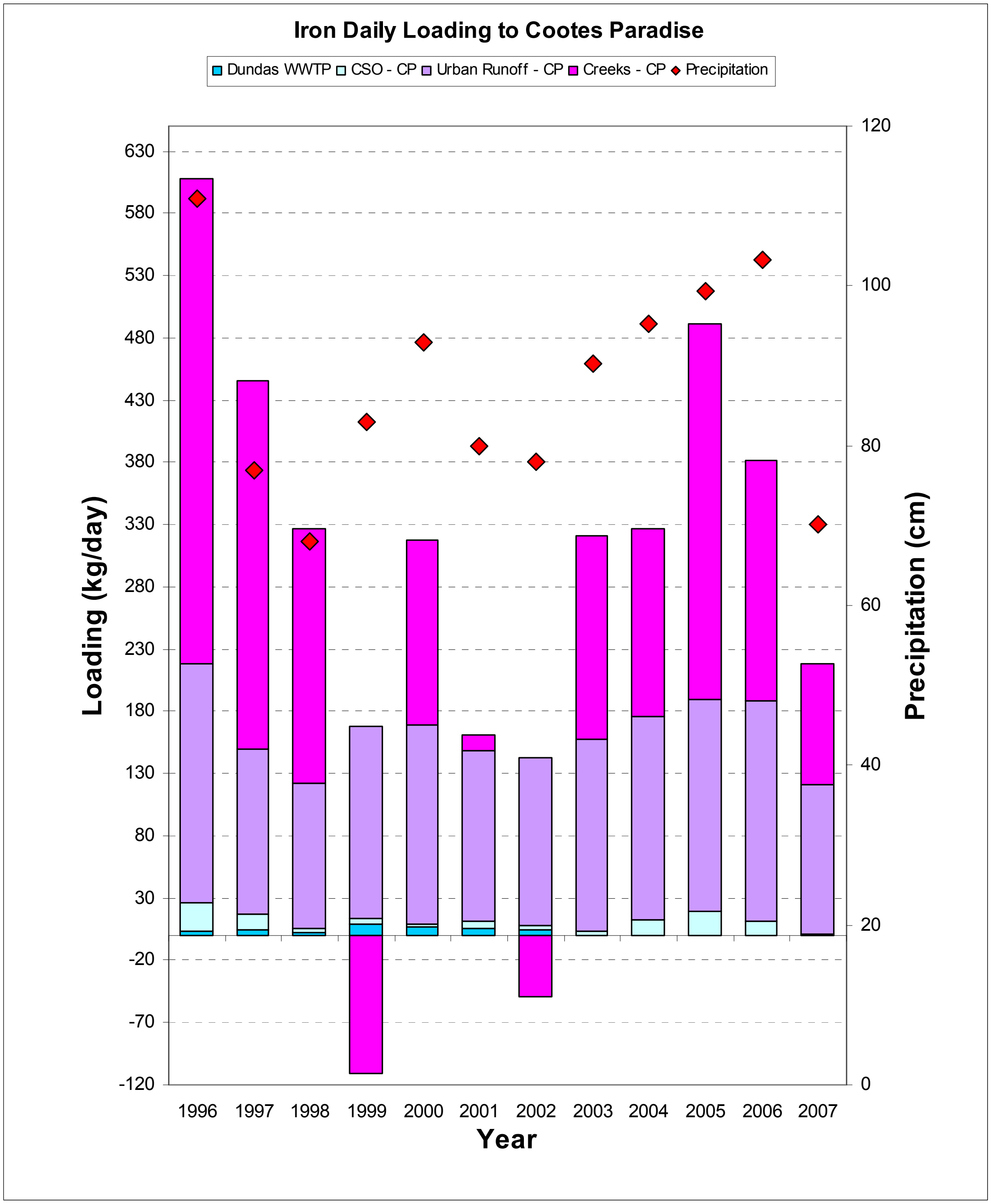

Figure 13. Iron Daily Loading to Cootes Paradise

8.6 Zinc (Zn)

Table 49. Estimated Zinc Loadings to Hamilton Harbour (kg/day)

ZINC	1996	1997	1998	1999	2000	2001	2002
Woodward WWTP	35	33	12	15	17	12	15
CSO	6	3	3	3	4	5	4
Skyway WWTP	2	2	2	< MDL	2	2	3
ArcelorMittal Dofasco	27	11	4	5	8	11	11
U. S. Steel Canada *	30	3	5	-2	4	6	5
Urban Runoff	8	6	5	6	7	6	6
Creeks – HH **	-0.4	-2	-0.2	-3	-1	-1	-3
Cootes Paradise	no data						
TOTAL	**107**	**56**	**30**	**25**	**41**	**40**	**41**

ZINC	2003	2004	2005	2006	2007
Woodward WWTP	20	18	18	17	11
CSO - HH	5	3	9	4	1
Skyway WWTP	4	3	4	2	3
ArcelorMittal Dofasco	27	9	9	7	14
U. S. Steel Canada	0	6	19	1	3
Urban Runoff - HH	7	7	7	8	5
Creeks - HH	no data – flow gauges not available				
Cootes Paradise	no data				
TOTAL	**62**	**46**	**65**	**38**	**38**

< MDL = concentrations were less than the method detection limit used

* As industries report net data instead of gross, a negative loading indicates the removal of more contaminant from the intake water than is put back through the effluent stream.

** As two different estimates are used to calculate creek loadings, a negative loading indicates the need to improve the methodology used not an actual net decrease in the contaminant.

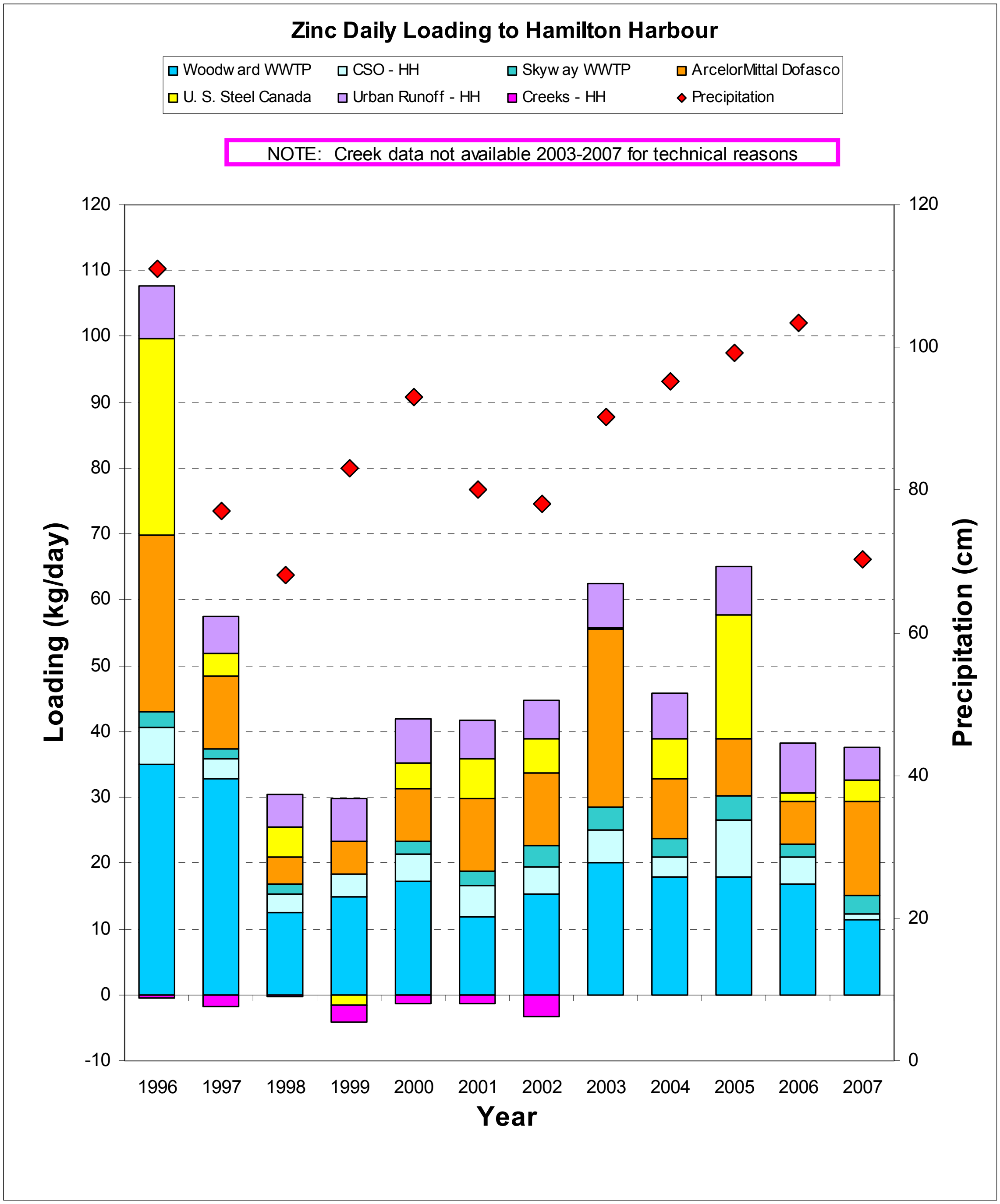

Figure 14. Zinc Daily Loading to Hamilton Harbour

Table 50. Estimated Zinc Loadings to Cootes Paradise (kg/day)

ZINC	1996	1997	1998	1999	2000	2001	2002
Dundas WWTP	< MDL	1.0	0.3	0.8	0.8	0.7	0.5
CSO - CP	0.7	0.4	0.1	0.2	0.1	0.2	0.1
Urban Runoff - CP	5.0	3.5	3.0	3.7	4.2	3.6	3.5
Creeks – CP *	11.1	8.2	5.6	-2.0	4.5	1.2	-0.5
TOTAL	**16.8**	**13.1**	**9.0**	**2.7**	**9.6**	**5.7**	**3.6**

ZINC	2003	2004	2005	2006	2007
Dundas WWTP	no data				
CSO - CP	1.0	0.4	0.6	0.4	0.02
Urban Runoff - CP	4.1	4.3	4.5	4.6	3.2
Creeks - CP	4.8	4.5	8.3	6.1	3.1
TOTAL	**9.9**	**9.2**	**13.4**	**11.1**	**6.3**

< MDL = concentrations were less than the method detection limit used

* As two different estimates are used to calculate creek loadings, a negative loading indicates the need to improve the methodology used not an actual net decrease in the contaminant.

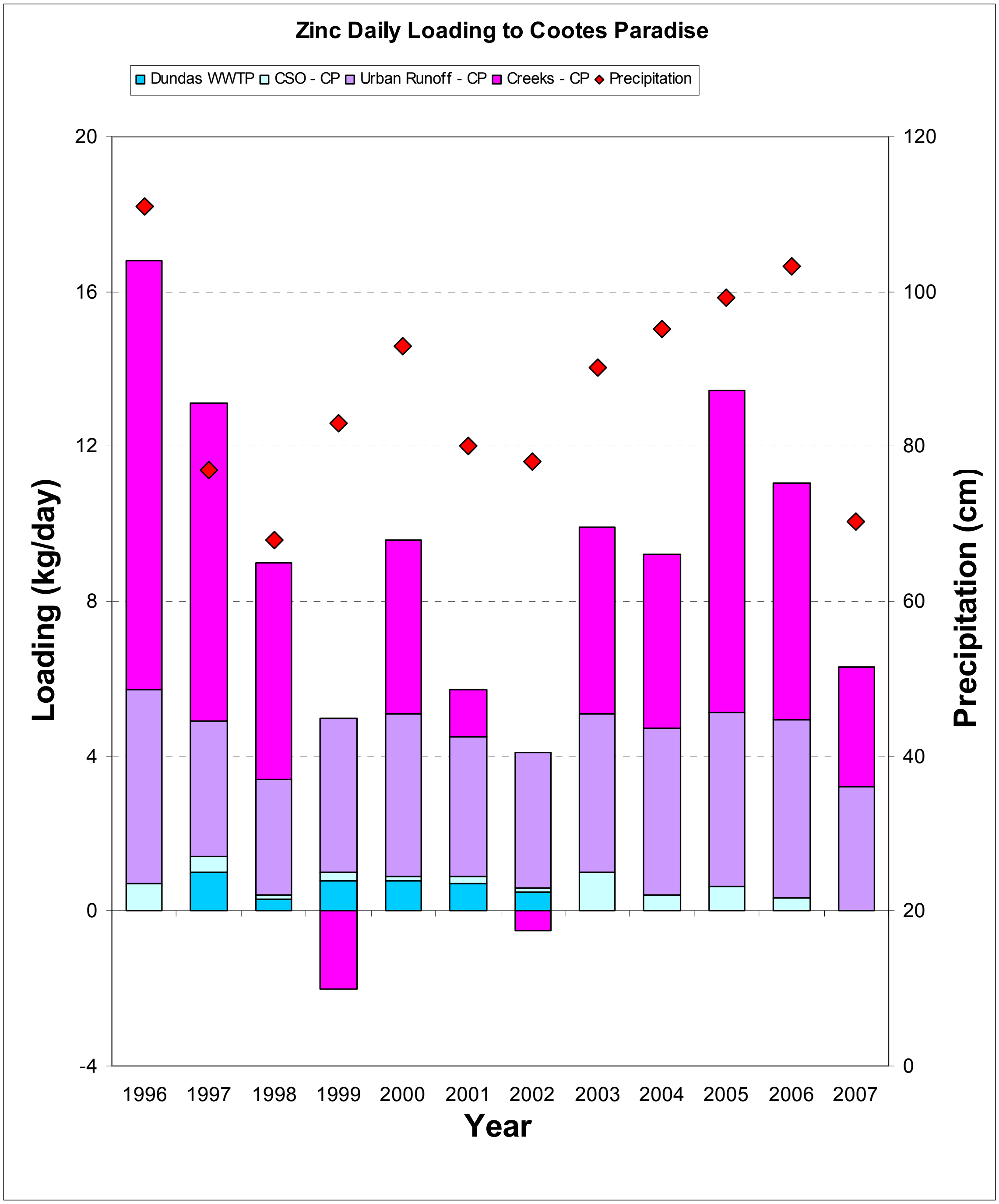

Figure 15. Zinc Daily Loading to Cootes Paradise

8.7 Phenolics

In the 1990-1996 Loadings Report, three sources of phenolics were reported: Dofasco, Stelco, and Cootes Paradise. The RAP Technical Team discussed the value of including Cootes Paradise estimates as a source, and decided that it should not be included in this report as there are no obvious inputs of phenolics into Cootes Paradise.

Table 51. Estimated Phenolics Loadings to Hamilton Harbour (kg/day)

PHENOLICS	1996	1997	1998	1999	2000	2001	2002
Woodward WWTP				no data			
CSO - HH				no data			
Skyway WWTP		< MDL		no data		< MDL	
ArcelorMittal Dofasco	8.4	2.2	0.8	1.4	1.6	1.4	1.1
U. S. Steel Canada	6.0	4.1	0.3	1.4	0.0	1.0	0.0
TOTAL	**14.5**	**6.4**	**1.2**	**2.8**	**1.7**	**2.5**	**1.2**

PHENOLICS	2003	2004	2005	2006	2007
Woodward WWTP	no data	1.7	2.0	1.6	no data
CSO - HH			no data		
Skyway WWTP	< MDL		no data		
ArcelorMittal Dofasco	0.4	0.9	1.1	2.4	0.9
U. S. Steel Canada	0.1	1.3	0.1	0.0	0.0
TOTAL	**0.5**	**3.9**	**3.2**	**4.0**	**0.9**

< MDL = concentrations were less than the method detection limit used

8.8 Cyanide

In the 1990-1996 Loadings Report, three sources of cyanide were reported: Dofasco, Stelco, and Cootes Paradise. The RAP Technical Team discussed the value of including Cootes Paradise estimates as a source, and decided that it should not be included in this report as there are no obvious inputs of cyanide into Cootes Paradise.

Table 52. Estimated Cyanide Loadings to Hamilton Harbour (kg/day)

CYANIDE	1996	1997	1998	1999	2000	2001	2002
Woodward WWTP	no data	44.8	26.6	14	23.1	29.5	27.5
CSO - HH	no data						
Skyway WWTP	no data						
ArcelorMittal Dofasco	23.1	3.3	0.1	6.4	5.1	7.6	0.7
U. S. Steel Canada	8.0	7.1	12.1	15.4	12.8	6.7	0.8
TOTAL	**31.1**	**10.4**	**12.2**	**21.8**	**17.9**	**14.3**	**1.5**

CYANIDE	2003	2004	2005	2006	2007
Woodward WWTP	30.9	22.7	25.6	25.3	30.9
CSO - HH	no data				
Skyway WWTP	no data				
ArcelorMittal Dofasco	0.2	-2.7	0.5	0.8	1.1
U. S. Steel Canada	1.0	2.6	1.0	1.6	1.2
TOTAL	**32.2**	**22.6**	**27.1**	**27.7**	**2.3**

8.9 Polycyclic Aromatic Hydrocarbons (PAHs)

No trend or pie charts were presented for PAHs in the 1990-1996 Loadings Report as there was not enough data to accurately estimate PAH loadings.

Dofasco and Stelco have provided the RAP Office with loadings data for two prominent PAHs, naphthalene and benzo(a)pyrene. As they both report net loadings resulting from the treatment of Harbour intake water, some of the values are negative. This would indicate the industry removed more of the contaminant from the water than they put back through their effluent stream. The fluctuation of values around zero may represent error in the sampling method more than an actual change in loading.

Table 53. Estimated Naphthalene Loadings to Hamilton Harbour (kg/day)

NAPHTHALENE	1996	1997	1998	1999	2000	2001	2002
Woodward WWTP	no data						
CSO - HH	no data						
Skyway WWTP	< MDL			no data	< MDL		
ArcelorMittal Dofasco *	0.2	-0.002	-0.01	0.02	-0.0003	0	0
U. S. Steel Canada *	-0.01	0.002	-0.06	-0.03	-0.0002	-0.001	-0.1
TOTAL	**0.2**	**0**	**-0.07**	**-0.01**	**-0.0005**	**-0.001**	**-0.1**

NAPHTHALENE	2003	2004	2005	2006	2007
Woodward WWTP	no data				
CSO - HH	no data				
Skyway WWTP	< MDL	no data			
ArcelorMittal Dofasco *	-0.01	0.00	0	-0.02	-0.01
U. S. Steel Canada *	-0.03	0.05	0.05	-0.01	0.00
TOTAL	**-0.04**	**0.05**	**0.05**	**-0.03**	**-0.01**

< MDL = concentrations were less than the method detection limit used

* As industries report net data instead of gross, a negative loading indicates the removal of more contaminant from the intake water than is put back through the effluent stream.

Table 54. Estimated Benzo(a)pyrene Loadings to Hamilton Harbour (kg/day)

BENZO(A)PYRENE	1996	1997	1998	1999	2000	2001	2002
Woodward WWTP	no data						
CSO - HH	no data						
Skyway WWTP	< MDL			no data	< MDL		
ArcelorMittal Dofasco *	0.1	0	0	0	-0.002	0	0
U. S. Steel Canada *	0.002	-0.004	0.006	-0.02	-0.07	0.006	0.02
TOTAL	**0.1**	**-0.004**	**0.006**	**-0.02**	**-0.07**	**0.006**	**0.02**

BENZO(A)PYRENE	2003	2004	2005	2006	2007
Woodward WWTP	no data				
CSO - HH	no data				
Skyway WWTP	< MDL	no data			
ArcelorMittal Dofasco *	-0.007	0.011	0	-0.003	-0.001
U. S. Steel Canada *	0.006	-0.007	-0.002	-0.007	0.04
TOTAL	**-0.001**	**0.004**	**-0.002**	**-0.01**	**0.04**

< MDL = concentrations were less than the method detection limit used

* As industries report net data instead of gross, a negative loading indicates the removal of more contaminant from the intake water than is put back through the effluent stream.

Appendix A. References

*NOTE: Reports available in the Hamilton Harbour RAP Library are given a catalogue number, these numbers appear in brackets after the reference (e.g. HH-****)*

Draper, D.W. and Associates Ltd. June 1993. Hamilton Harbour Tributaries Storm Event Monitoring Study. (Final Report to Hamilton Region Conservation Authority) *(HH-0787)*

Gale, D. and J. Hall. October 1999. Headwaters to the Bay: Planning for Sustainability in the Hamilton Harbour Watershed. *(HH-1462)*

Hamilton Harbour RAP. September 1998. Remedial Action Plan for Hamilton Harbour. 1998 Status Report. Third Printing, March 1999. ISBN 0-662-27238-2 *(HH-1554)*

Hamilton Harbour RAP. Nov 1992. The Remedial Action Plan: Goals, Options, Recommendations. Volume 2 – The Report. Stage 2A Report. ISBN 0-7778-0533-2 *(HH-1814)*

Hamilton Harbour RAP Stakeholders. June 2003. Hamilton Harbour Remedial Action Plan: Stage 2 Update 2002. ISBN 0-9733779-0-9 *(HH-2050)*

Hamilton Harbour RAP Technical Team. March 2004. 1996-2002 Contaminant Loadings and Concentrations to Hamilton Harbour. ISBN 0-9733779-3-3

Labencki, T. August 2008. An Assessment of Polychlorinated Biphenyls (PCBs) in the Hamilton Harbour Area of Concern (AOC) in Support of the Beneficial Use Impairment (BUI): *Restrictions on Fish and Wildlife Consumption*. ISBN: 978-0-9810874-0-5

Labencki, T. December 2009. 2007 Field Season in the Hamilton Harbour Area of Concern. PCB and PAH water monitoring undertaken by the Ontario Ministry of the Environment to support mass balance work by the Hamilton Harbour Remedial Action Plan (RAP) on PAH contamination at Randle Reef and PCB contamination in Windermere Arm. ISBN: 978-0-9810874-2-9

Marsalek, J. and H.Y.F. Ng. 1989. Evaluation of Pollution Loadings from Urban NonPoint Sources: Methodology and Applications. J. Great Lakes Res. 15(3):444-451. *(HH-244)*

Marsalek, J. and H. Schroeter. 1988. Annual Loadings of Toxic Contaminants in Urban Runoff From the Canadian Great Lakes Basin. Water Poll. Res. J. Canada 23(3):360-378. *(HH-1592)*

Maunder, D., Whyte, R. and D'Andrea, M. 1995. Metropolitan Toronto Waterfront Wet Weather Outfall Study * Phase II City of Toronto, Report prepared for the Metropolitan and Region RAP by Aquafor Beech Limited, Ontario Ministry of Environment and Energy. ISBN 0-7778-4787-6

Theil, P. and Beak Consultants. 1991. Pollution Control Plan (A Report prepared for the Regional Municipality of Hamilton-Wentworth) *(HH-0486)*

Water Technology International Corporation, J. Vogt, Hamilton Harbour RAP Office. June 1998. Summary Report. 1990-1996 Contaminant Loadings and Concentrations to Hamilton Harbour. *(HH-1206)*

Weatherbe, Donald G. September 1990. Review of Urban Non-Point Source Pollution Problems and Control for RAP Areas. Presentation to RAP Coordinators, September 12, 1990. *(HH-1383)*

Appendix B. Hamilton Harbour "A" and "B" List Toxic Chemicals

(Reprinted from p.81 of the "Stage 2 Update 2002" Report)

The Hamilton Harbour RAP Toxic Substances Task Group has assigned chemicals or chemical classes of contaminants of concern into one of two lists. These classifications are based on the Task Group's assessments of the impacts of these contaminants on the Harbour. This classification by priority was designed to facilitate the allocation of monitoring, abatement, and remediation resources so that delisting criteria can be met in the shortest timeframe.

The "A" list of contaminants includes compounds that are prevalent in the Harbour at levels that pose significant risk to fish and wildlife. These compounds include polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and a number of toxic metals. Levels of these compounds exceed provincial and/or federal water, sediment, or tissue guidelines designed for the protection of aquatic biota, and significantly exceed ambient levels in Lake Ontario. These compounds are also responsible for beneficial use impairments related to toxic contaminants. Coal tar-contaminated areas of the Harbour (e.g., Randle Reef) and contemporary sources of these compounds must be identified and remedial measures implemented before delisting criteria can be achieved. Mercury has been added to the "A" list because some forms of mercury are highly toxic; inclusion on the list is due in part to the shortage of information regarding current levels of mercury in the Harbour.

Hamilton Harbour "A" List Toxic Chemicals

- Polycyclic Aromatic Hydrocarbons (PAHs)
- Polychlorinated Biphenyls (PCBs)
- Toxic Metals (arsenic, cadmium, iron, lead and zinc)
- Mercury

The "B" list of contaminants includes some compounds that are highly toxic, but have not been demonstrated to be present in Hamilton Harbour at levels that threaten fish or wildlife. Examples include dioxins and furans, which have been detected in Harbour sediments at levels similar to other areas of Lake Ontario where fish and wildlife are not adversely impacted. Any of the "B" list compounds may be designated as "A" list contaminants should current or future studies identify potential threats to the ecosystem due to these substances.

Hamilton Harbour "B" List Toxic Chemicals

- Dioxins and Furans
- Organochlorine Pesticides (e.g. DDT)
- Current Use Pesticides (e.g. 2,4-D)
- Endocrine-Disrupting Compounds (EDCs)
- Ammonia