

**Process to Identify Priority Substances of
Health Concern for
Enhanced Environmental Reporting**

Technical Summary

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Technical Basis: This document draws on a technical review prepared for Toronto Public Health by Marshall, Macklin, and Monaghan, Dr. Harvey Shear from the University of Toronto, and LURA Consulting entitled: *Substances of Concern Release and Transfer Reporting in Toronto: Analysis of Gaps*. May 2007. This report is available on the website at:
www.toronto.ca/health/hphe/enviro_info.htm.

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Executive Summary

Toronto Public Health (TPH) conducted research and consulted with City staff and external stakeholders on options for Toronto to prevent pollution and reduce health risks through enhanced access to environmental information (also known as “community right-to-know”).

The need to increase environmental reporting in Toronto was based on the assessment of whether current reporting is capturing the majority of substances released. Data that were readily accessible to the public were used to estimate the total emissions and the gaps in reporting of emissions of substances of concern. The gaps in reporting were estimated by external researchers. The gaps were estimated based on the amounts of substances released (by weight).

Toxic substances are released in Toronto in vastly different quantities ranging from a fraction of a tonne to over 5,000 tonnes per facility each year. These substances also vary in their toxicity. Some substances are extremely toxic that even very small quantities can pose a significant health risk if present. Other substances have low toxicity, so that even when released in large quantities, the health risk is not significant.

Three approaches were used to identify priorities for enhanced environmental reporting based on the potential for the substance to impact the health of Toronto residents. These approaches were:

- Prioritizing estimated emissions data using a health-based ranking scheme;
- Identifying substances in Toronto’s air that exceed health-based benchmarks; and
- Identifying common greenhouse gases that contribute to climate change.

Institutional, commercial and industrial operations (referred to as businesses) in Toronto release one or more of the 25 toxic substances of priority health concern into the air. These priority substances occur in the Toronto environment at levels that pose a risk to health. These substances include carcinogens such as cadmium, trichloroethylene and formaldehyde. For Toronto residents, emissions to air are the most important route of exposure for toxic substances, and hence pose the greatest health risk. Businesses also release greenhouse gases that contribute to climate change and associated health impacts.

Toronto businesses report very little information on their emissions because reporting thresholds for mandatory national and provincial programs are very high. Currently, only 3% of Toronto businesses report to the publicly accessible National Pollutant Release Inventory (NPRI). More than 80 per cent of estimated emissions to air for TPH’s 25 priority substances are not reported to the NPRI.

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Purpose of the Study

Toronto Public Health (TPH) conducted research and consulted with City staff and external stakeholders on options for Toronto to prevent pollution and reduce health risks through enhanced access to environmental information (also known as “community right to know”).

At the stakeholder consultations, opinions differed regarding the need for enhanced reporting on substances used and emitted in Toronto. However, participants did agree that any enhanced environmental reporting should be focussed on substances of priority health concern.

This report addresses two issues:

- the need to increase environmental reporting in Toronto; and
- establishing priority substances for enhanced environmental reporting in Toronto.

Determining the Need to Increase Environmental Reporting in Toronto

The need to increase environmental reporting in Toronto was based on whether current reporting is capturing the majority of substances released. Data that were readily accessible to the public were used to estimate the total emissions and the gaps in reporting of emissions of substances of concern.¹

The gaps in reporting were estimated by a team led by Marshall Macklin Monaghan and Dr. Harvey Shear of the University of Toronto. The study method and findings are described in detail in the report “Substances of Concern, Release and Transfer Reporting in Toronto: Analysis of Gaps” available at http://www.toronto.ca/health/hphe/enviro_info.htm. The analysis provides estimates of the amount of substances released (emitted),² transferred and used, by substance and by sector. The gaps in reporting were estimated as the amounts released by weight. No estimates were made of storage of substances because no databases or methods were available to provide estimates.

¹ Substances of concern are defined as those substances that are reported to the National Pollutant Release Inventory.

² Releases – refers to the amount of chemicals or toxic substances that are released from sites into the environment through:

- a) Air emissions from point sources (example, stacks), operational losses, fugitive emissions, spills and accidents;
- b) Discharges to surface water either through direct discharge, leaks or spills; or
- c) Discharge or disposal to land within the site.

Eighteen sectors with the potential for the release of substances of concern in Toronto were identified:

- | | |
|-----------------------------------|---------------------------------------|
| - Food and Beverage Manufacturing | - Medical and Diagnostic Laboratories |
| - Clothing Manufacturing | - Automotive Repair and Maintenance |
| - Printing and Publishing | - Fuelling Services |
| - Chemical Manufacturing | - Transportation Support |
| - Wood Industries | - Construction |
| - Other Manufacturing | - Laundry Services (Dry Cleaning) |
| - Chemical Distribution | - Funeral Services |
| - Waste Management | - Power Generation |
| - Water Treatment | - Property Management/Institutional |

Based on a review of various listings of substances of concern, the National Pollutant Release Inventory (NPRI) list of substances of concern was selected to be representative of the substances likely to be used and released in Toronto. In 2005, 323 substances were reported through the National Pollutant Release Inventory (NPRI) program.

Data on the amount released reported through NPRI were extrapolated using Toronto employment data (City of Toronto, 2005) to estimate total quantities, that is both quantities reported through NPRI and quantities released by businesses that do not report through NPRI). Emission factors were used to estimate emissions for those sectors that do not report to NPRI. Both reported and unreported emissions were estimated and total emission estimates were provided.

The key findings are:

- Out of the possible 323 substances on the NPRI list, less than 100 substances are reported in Toronto.
- Only 3 per cent of Toronto businesses report
- Most small and medium sized businesses do not report
- The majority of Toronto's releases are to air (higher than 99 per cent for all sectors, except the waste management sector for which releases are greatest to water).
- Greenhouse gas emissions (eCO₂) are not reported
- Approximately 60 per cent of total releases in Toronto (air, water and land) are not reported to NPRI.
- Approximately 80 per cent of releases to air are not reported to NPRI³.
- No use and storage data are reported in Toronto.

³ Environment Canada (EC, 2007) estimated that the reporting gap for Toronto's emissions to air is approximately 70 per cent. EC's estimates are based on NPRI data on point source emissions to air for 2002 and the OMOE's emissions inventory for area sources to air. The small differences in the estimates are most likely due to differences in the year estimated and the different sources of data.

Emissions to air are the most significant in terms of the amount released, the gaps in reporting, and the potential hazard for Toronto residents. Based on these results, TPH concludes that there is a need for enhanced reporting of substances of concern in Toronto with a priority on emissions to air.

Approach to Establishing Health Priorities for Enhanced Environmental Reporting in Toronto

Toxic substances are released in Toronto in vastly different quantities ranging from a fraction of a tonne to over 5,000 tonnes per facility each year. These substances also vary in their toxicity. Some substances are extremely toxic such that even in very small quantities, they can pose a significant health risk. Other substances have low toxicity, so that even when released in large quantities, the health risk is not significant.

Three approaches were used to identify priorities for enhanced environmental reporting based on the potential for the substance to impact the health of Toronto's residents. These approaches were:

- Prioritizing estimated emissions data using a health-based ranking scheme;
- Identifying substances in Toronto's air that exceed health-based benchmarks; and
- Identifying common greenhouse gases that contribute to climate change.

1. Estimated emissions data were assessed using a health-based ranking scheme

Using the estimates of emissions, TPH applied a ranking scheme known as Toxicity Equivalence Potentials (TEP) which is based on a method developed at the University of Berkeley, California (Hertwich et al., 2001). The method uses estimates of the amount of substances released and then:

- Considers the movement of the substance (from point of release to contact with a person);
- Factors in the toxicity of the substance (cancer and non-cancer effects); and
- Provides a risk score (to enable comparison of substances with different toxicities).

The method was developed to compare the potential health impact of substances by combining the amount of the substance released with its toxicity. In this risk scoring system, all releases of substances are converted into a common unit of TEPs (related either to benzene [carcinogen] or toluene [non-carcinogen]). The individual TEPs generated for each substance can be compared between substances, businesses, sectors, years, and policy-scenarios, thereby providing a ranking of the toxicity-weighted releases. Table 1 presents the 25 substances of priority health concern with; the amount

they are released to air; their TEP value (their relative toxicity to benzene for carcinogens and toluene for non-carcinogens); and, their TEP-scores. The higher the number is, the higher the risk potential for the substance. Each value is followed by a number in brackets. This number is the ranking of the substance relative to the 96 substances that were included in this analysis.

TPH found that the vast majority of the risk associated with air emissions in Toronto can be attributed to three substances: mercury, cadmium, and lead.⁴ These three substances are released in relatively small quantities in Toronto's air. However, they are very toxic substances.⁵ When air emissions are ranked by toxicity, cadmium, mercury and lead are the most important to health.

2. Current air quality data were compared to health-based benchmarks

TPH obtained air quality data from Environment Canada and the Ontario Ministry of the Environment (OMOE).⁶ We used air quality data of samples taken from Toronto to assess whether there were any toxic substances in Toronto air that currently exceeded health-based benchmarks. We used the health-based benchmarks developed by California Environmental Protection Agency (CalEPA) and the OMOE.⁷

A substance was considered a priority if the maximum air concentration measured in Toronto's air exceeded either the CalEPA health-based benchmarks or OMOE ambient air quality criteria (AAQC).⁸ Table 2 presents the substances of priority health concern with the exposure ratio for the substances concentration in Toronto's air compared to a health-based benchmark. The benchmark that is exceeded is also presented in Table 2.

We identified 22 substances that currently exceed health-based benchmarks in Toronto's air. These substances are sometimes found in Toronto's air at levels that exceed one-in-a-

⁴ Calculated by identifying the substances that accounted for higher than 99 per cent of the total TEP for Toronto.

⁵ Cadmium and lead are carcinogens. Mercury and lead are neurotoxins.

⁶ The air data were provided by Tom Dann, Environment Canada. The air samples were taken between 2003 and 2005 at three NAPS stations in Toronto. The sample sizes were different for contaminant classes (VOC = 616; metals = 281; PAHs = 183). Criteria air contaminant concentrations were taken from the OMOE's annual summary on criteria air contaminants (CACs) in Ontario for 2005. The OMOE uses continuous monitoring instruments. There are five sample sites in Toronto. Only four of these samples were used because one is 444 metres above ground (CN Tower) and not considered relevant to human exposure. Mercury air concentrations were taken from Senes. 2000. Report on Ambient Air Monitoring and Source Testing at the St. John's Norway Crematorium. Senes Consultants Limited. Only three samples were available.

⁷ The CalEPA toxicological database was used (unit risk and chronic reference exposure levels [CRELs]) because it is a reputable source of toxicological information and it provides more complete coverage of substances of concern. The OMOE ambient air quality criteria (AAQC) were used because of its regulatory relevance to Toronto.

⁸ The maximum air concentrations were used in this assessment because there were limited sample sites and it is known that the average concentrations at these sites can underestimate the air concentrations of contaminants to which people are exposed (TPH, 2005). Thus, TPH used the maximum air concentration measured in order to be health protective.

million cancer risk and/or a level at which unacceptable adverse effects may occur (such as neurotoxicity, reproductive effects, and effects on the kidney).

Toluene is estimated to be the highest emitted air toxic in Toronto and Ontario. The indirect effects of toluene on smog formation are of critical importance to the health of the citizens of Toronto. Based on the current burden of illness study, TPH estimates that air pollution in our city contributes to about 1,700 premature deaths and 6,000 hospitalizations on an annual basis.

TPH is concerned about potential health impacts from long-term exposure to these substances or combinations of them. Consequently, these substances were considered priorities for enhanced reporting of releases in Toronto.

These substances are:

Acetaldehyde	Ethylene dibromide
Acrolein	Formaldehyde
Benzene	Particulate Matter (PM _{2.5})
1,3-Butadiene	Manganese
Cadmium	Nickel
Carbon Tetrachloride	NOx (nitrogen oxides)
Chloroform	PAHs (polycyclic aromatic hydrocarbons)
Chloromethane	Tetrachloroethylene
Chromium	Toluene
1,4-Dichlorobenzene	Trichloroethylene
1,2-Dichloroethane	Vinyl chloride
Dichloromethane	

3. Considering the substances that contribute to climate change

Climate change has been considered the most critical public health and environmental issue of our time. Although, greenhouse gases are not included in NPRI, the importance of climate change as a significant health issue of concern warrants consideration of the inclusion of carbon dioxide equivalents (eCO₂) in the list of priorities. There is a National Greenhouse Gas Registry; however, no businesses in Toronto are required to report to it. This is because the threshold for reporting is very high - 100,000 tonnes of eCO₂. Greenhouse gas emissions reported to the national registry include:

- Carbon dioxide (CO₂)
- Methane (CH₄)
- Nitrous oxide (N₂O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulfur hexafluoride (SF₆)

Discussion of Findings

The results of this priority setting exercise are supported by a number of other studies. These studies also identify these substances as priority toxic substances for Toronto (Campbell et al., 1995; TPH, 2002; TPH, 2005; EC, 2007).

Cadmium, mercury, and lead were identified as priorities using the TEP ranking approach. However, mercury and lead were not found to currently exceed health-based benchmarks in Toronto's air. This is not unexpected. Due to their physical-chemical properties, lead and mercury have been found in other media (soil, sediment, and biota) that exceed health-based benchmarks. All 25 substances of priority health concern are found in Toronto's environment at levels at which unacceptable adverse effects may be occurring.

The average contribution of mobile sources to each substance of priority health concern was estimated using the OMOE's emission inventory. The OMOE's estimates are available for each county in Ontario, as well as the Greater Toronto Area. The OMOE's assessment considered large point sources, numerous small point (area) sources, residential, and mobile (on- and off-road) sources. Using this data, TPH calculated that for the substances of priority health concern, mobile sources contribute on average less than 40 per cent of the total amounts released to air. This finding is consistent with the generally observed contribution of mobile sources to urban air toxics (MPCA, 2005; US EPA 2002).

There are no data available to estimate the contribution of transboundary sources to the substances of priority health concern (from the U.S. and neighbouring municipalities). The OMOE estimates that transboundary sources of the criteria air pollutants are significant, particularly on smog days. For example, the OMOE estimates that the U.S. is responsible for at least 50 per cent of ozone during smog events at locations in southern Ontario (OMOE, 2003).

While transboundary and mobile sources are expected to provide an important contribution to the substances of priority health concern in Toronto, local sources are also a significant source of these contaminants. In order to better understand the contribution of small and medium sized point and area sources, we need data on these substances released in Toronto.

The air quality data used in our analysis and the TEP estimates provide a general overview of relative health risk associated with air pollutants in Toronto. They are intended to be used to rank priorities and not provide a definitive assessment on the risks of particular substances to Toronto residents.

Summary and Recommendations

Currently, only 3 per cent of Toronto businesses report emissions to the NPRI. More than 80 per cent of air emissions of substances of priority health concern are not reported. For Toronto residents, emissions to air are the most important route of exposure for these toxics.

TPH concluded there is a need for enhanced reporting and access to environmental information in Toronto. TPH identified the following 25 toxic substances as being of priority concern for health: acetaldehyde, acrolein, benzene, 1,3-butadiene, cadmium, carbon tetrachloride, chloroform, chloromethane, chromium, 1,4-dichlorobenzene, 1,2-dichloroethane, dichloromethane, ethylene dibromide, formaldehyde, lead, PM_{2.5}, manganese, mercury, nickel, NO_x, polycyclic aromatic hydrocarbons (PAHs), tetrachloroethylene, toluene, trichloroethylene and vinyl chloride.

It is recommended that policies be developed to enhance reporting of the 25 substances of priority health concern. In addition, it is recommended that consideration be given to the inclusion of greenhouse gases in the development of an enhanced environmental reporting program.

References

Campbell, M.E., Benson, B.A., and Muir M.A. 1995. Urban Air Quality and Human Health: A Toronto Perspective. *Canadian Journal of Public Health*. 86(5):351-356.

City of Toronto, *Toronto Business Directory*. Economic Research, Economic Development, City of Toronto. 2005.

Environment Canada. 2006. Personal Communication. Tom Dann to Toronto Public Health via email on November 29, 2006.

Environment Canada. 2007. Personal Communication. Dylan Morgan to Toronto Public Health via email on March 28, 2007.

Hertwich, E.G., S. Mateles, W.S. Pease, and T. McKone. Human toxicity potentials for life cycle assessment and Toxics Release Inventory risk screening. *Environmental Toxicology and Chemistry* 20(4):928-939. 2001.

MPCA. 2005. Air pollution from Mobile Sources. General Public #5-07, April 2005. Minnesota Pollution Control Agency.

OMOE. 2004. 2001 Inventory of Toxic Air Emissions: Point, Area, and Mobile Sources for Toronto Metropolitan Municipality. April 2004. Great Lake Commission, Ontario Ministry of the Environment.

OMOE. 2006. Air Quality in Ontario 2000 Report. Ontario Ministry of the Environment.

TPH, 2002. Ten Key Carcinogens in Toronto Workplaces and Environment: Assessing the Potential for Exposure. Toronto Public Health.

TPH, 2005. Improving Toronto's Air Quality: Areas for Priority Action. Toronto Public Health. Toronto Atmospheric Fund.

US EPA. 2006. National-scale air toxics assessment overview: the 33 pollutants. Technology Transfer Network. National Air Toxics Assessment. US EPA. <http://www.epa.gov/ttn/atw/nata/34poll.html>. Accessed: April 2, 2007.

Table 1: Substances of Priority Health Concern presented with the Amount Released to Air, Toxic Equivalency Potential (TEP) Values, TEP-Scores¹, and Relative Rank².

Priority Substance of Health Concern	Amount Released (Rank)	TEP-Carcinogen	TEP Score ¹ for Carcinogens (Rank)	TEP-Non Carcinogen	TEP Score ¹ for Non-Carcinogens (Rank)
	A (tonnage)	B	=AxB	C	=AxC
Nitrogen Oxides	6900 (2)	n/a	n/a	2.2	35,000,000 (8)
PM_{2.5}	2400 (6)	n/a	n/a	17	90,000,000 (4)
Toluene	625 (8)	n/a	n/a	1	1,300,000 (22)
Tetrachloroethylene	225 (14)	1	480,000 (4)	65	32,000,000 (9)
Dichloromethane	165 (18)	0.2	73,000 (5)	7	2,600,000 (18)
Lead	36 (29)	28	2,200,000 (2)	580000	47,000,000,000 (2)
Formaldehyde	24 (30)	0.02	1,000 (11)	16	840,000 (25)
Mercury	13 (38)	n/a	n/a	5000000	140,000,000,000 (1)
Cadmium	8 (40)	26000	430,000,000 (1)	190000	3,200,000,000 (3)
Chromium	5 (43)	130	1,500,000 (3)	3100	35,000,000 (7)
Trichloroethylene	3 (50)	0.05	260 (12)	0.6	3,200 (50)
Nickel	1 (55)	3	6,000 (9)	3200	6,800,000 (14)
Manganese	1 (56)	n/a	n/a	780	1,600,000 (20)
Benzene	0.1 (67)	1	210 (13)	8	1,700 (53)
Carbon Tetrachloride	n/ed	270	n/ed	2300	n/ed
Acrolein	n/ed	n/a	n/ed	1600	n/ed
Vinyl chloride	n/ed	2	n/ed	68	n/ed
Chloromethane	n/ed	0.7	n/ed	57	n/ed
Chloroform	n/ed	2	n/ed	14	n/ed
Acetaldehyde	n/ed	0.01	n/ed	9	n/ed
1,2-Dichloroethane	n/ed	3	n/ed	4	n/ed
1,4-Dichlorobenzene	n/ed	1	n/ed	2	n/ed
1,3-Butadiene	n/ed	0.5	n/ed	2	n/ed
Ethylene dibromide	n/ed	n/a	n/ed	n/a	n/ed
PAHs	n/ed	6300 ³	n/ed	n/a	n/ed

n/a No TEP available

n/ed No emissions data available

¹ TEP Score = Amount Released (converted to pounds) x TEP (carcinogen; non-carcinogen)

² Substances were ranked against the total list of substances released in Toronto. Ninety six substances were assessed. Ranks are presented in brackets ().

³ Benzo(a)pyrene used as a surrogate for the group of substances

Table 2: Substances of Priority Health Concern presented with Measured Air Concentrations for 2003 to 2005, Exposure Ratios, and the health-based benchmarks exceeded.

Priority Substances	Exposure Ratio ¹	Benchmarks Exceeded ²
Chromium ³	1150	CalEPA Unit Risk
Benzene	176	CalEPA Unit Risk
PAHs ⁴	302	CalEPA Unit Risk
1,3-Butadiene	102	CalEPA Unit Risk
Formaldehyde	67	CalEPA Unit Risk; CalEPA CREL
1,4-Dichlorobenzene	41	CalEPA Unit Risk
Carbon tetrachloride	34	CalEPA Unit Risk
Cadmium	25	CalEPA Unit Risk; MOE Proposed AAQC
Acrolein	20	MOE AAQC; CalEPA CREL; CalEPA Acute REL
Acetaldehyde	15	CalEPA Unit Risk
Dichloromethane	14	CalEPA Unit Risk
Tetrachloroethylene	12	CalEPA Unit Risk
Ethylene dibromide	7	CalEPA Unit Risk
Trichloroethylene	6	CalEPA Unit Risk; MOE Proposed AAQC
Nickel compounds	4	CalEPA Unit Risk
Vinyl chloride	4	CalEPA Unit Risk
Chloroform	3	CalEPA Unit Risk
Chloromethane	3	NJ DEP
NO _x	3	MOE AAQC
1,2-Dichloroethane	3	CalEPA Unit Risk
PM _{2.5}	2	MOE AAQC
Manganese	2	CalEPA CREL
Lead	0.4	None
Toluene	0.1	None
Mercury	0.00018	None

¹ Exposure Ratio = Maximum measured air concentration ÷ health based benchmarks. The highest exposure ratio is presented, if multiple benchmarks were exceeded.

² CalEPA Unit Risk = California Environmental Protection Agency Unit Risk;
CalEPA CREL = California Environmental Protection Agency Chronic Reference Exposure Levels (Acute when indicated);

MOE AAQC = Ontario Ministry of the Environment Ambient Air Quality Criteria

US EPA Unit risk = United States Environmental Protection Agency Unit Risk

³ Benchmarks for hexavalent chromium used as a surrogate for the group of substances. It was assumed that 15% of the total chromium air concentration was hexavalent chromium.

⁴ Air concentration used is the sum of 20 individual PAHs. Benchmarks for benzo(a)pyrene used as a surrogate for the group of substances.

Benchmarks Extracted From:

MOE. 2005. Summary of O. Reg. 419/05 Standards and Point of Impingement Guidelines and Ambient Air Quality Criteria (AAQCs). Standards Development Branch. Ontario Ministry of the Environment. December 2005.

Air Quality in Ontario 2005 Report: December, 2006. MOE.

<http://www.ene.gov.on.ca/envision/techdocs/6041e.pdf>

CalEPA CRELs (chronic) http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html

CalEPA Cancer Unit Risk http://www.oehha.ca.gov/air/hot_spots/pdf/TSDlookup2002.pdf

CalEPA CRELs (acute) http://www.oehha.ca.gov/air/acute_rels/allAcRELS.html

NJ DEP <http://www.nj.gov/dep/aqpp/downloads/risk/Risk2007.xls>