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Health and Environmental Data in the Great Lakes Basin - Integrating Data Collection and Analysis

Priority on Capacity and Capability to Coordinate and Deliver Science
Including Data Integration and Access
2012-2015 Priority Series



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List of Abbreviations and Acronyms

APS	Aboriginal People Survey	ICES	Institute for Clinical Evaluative Sciences
AQS	Air Quality System	IADN	Integrated Atmospheric Deposition Network
AOC	Areas of Concern		International Information System on Occupational Exposure to Carcinogens
BRFSS	Behavioral Risk Factor Surveillance System	CAREX	
BORN	Better Outcomes Registry & Network	IJC	International Joint Commission
BEC	Binational Executive Committee	MIREC	Maternal-Infant Research on Environmental Chemicals
CAPMON	Canadian Air and Precipitation Monitoring Network	NAPS	National Air Pollution Surveillance
CCR	Canadian Cancer Registry	NCHS	National Center for Health Statistics
CCHS	Canadian Community Health Survey	NEI	National Emissions Inventory
CHMS	Canadian Health Measure Survey	NHANES	National Health and Nutrition Examination Survey
CHILD	Canadian Healthy Infant Longitudinal Development	NHIS	National Health Interview Survey
CIHI	Canadian Institute of Health Information	NHGIS	National Historical Geographic information System
CPSP	Canadian Paediatric Surveillance Program	NHEXAS	National Human Exposure Assessment Survey
CANSIM	Canadian Socio-Economic Information Management System	NOAA	National Oceanic and Atmospheric Administration
CDC	Centers for Diseases Control and Prevention	NPRI	National Pollutant Release Inventory
CMP	Chemical Management Plan	NPHS	National Population Health Survey
DDE	dichlorodiphenyldichloroethylene	NVSS	National Vital Statistics System
DDT	dichloro-diphenyl-trichlorethane	LPP	Ontario Lake Partner Program
DALY	Disability Adjusted Life Year	OMOE	Ontario Ministry of Environment
EAGLE	Effects on Aboriginals from the Great Lakes Environment	PCB	polychlorinated biphenyl
EPA	Environmental Protection Agency	PRAM	Pregnancy Risk Assessment Monitoring System
FEMS	Farm Environmental Management Survey	QALY	Quality Adjusted Life Year
FDA	Food and Drug Administration	SOLEC	State of Lakes Ecosystem Conference
GIS	Geographic Information Systems	TDS	Total Diet Study
GLENDATA	Great Lakes Environmental Database	TRI	Toxic Release Inventory
GLWQM	Great Lakes Nearshore Monitoring and Assessment Program	US	United States
GLOS	Great Lakes Observing System	USCS	United States Cancer Statistics
HPAB	Health Professional Advisory Board	WHO	World Health Organization
HERS	Hedgehog Environmental Reporting System		

1 Executive Summary

This report was produced by the International Joint Commission (IJC) Health Professionals Advisory Board for the IJC Commissioners for their information and assistance in reporting and providing advice to the parties under the terms of the Great Lakes Water Quality Agreement. The report may also be useful to other public health and environmental scientists and managers seeking improved databases to make more informed decisions to protect and restore the Great Lakes ecosystem and the public health of its residents.

In 2012, the IJC's Health Professional Advisory Board (HPAB) initiated the Integration of Great Lakes Basin Human Health-Environmental Surveillance project to address the growing need for integrated environmental and human health data. Through a series of consultations with health and environmental experts in Canada and the United States and a literature review, a comprehensive analysis was conducted to review existing environmental and human health datasets in the Great Lakes area and to identify opportunities and challenges for integrating these data.

Datasets were identified and organized according to the type of data collected including: environmental stressors, environmental hazards, human exposure and human health outcomes. Over 250 health and environmental datasets were retrieved and reviewed in the search with the vast majority falling in the environmental hazards and health outcomes categories and relatively few in the environmental stressors and human exposures categories. Key factors that impact integration were identified and include data availability, accessibility, harmonization, stakeholder collaboration, policy and strategic alignment, resource adequacy, environmental-human health indicators and data exchange networks.

Currently neither health nor environmental exposure data are collected in a way that allows examination of associations in the Great Lakes ecosystem. The existing national health surveys, although designed to be nationally representative, cannot be used to ascertain environmental health risks for the Great Lakes Basin and compare them to the rest of the two countries. The HPAB has developed the following set of recommendations to address these basic concerns:

Recommendation #1: That governments actively engage with public health practitioners, academic researchers, and community groups that represent vulnerable communities in the Great Lakes Basin to identify priority areas for data integration. This report has illustrated the vast data sources that could potentially be integrated, however, it will be important for the data users to identify knowledge gaps and priorities for surveillance that the integration process could address.

Recommendation #2: That governments explore the potential of building onto databases already in place (e.g., Great Lakes Observing System) and/or projects that have already developed exposure estimate techniques and models for similar purposes (e.g., CAREX Canada).

These existing projects have the potential to be extended by sampling in the Great Lakes Basin to develop a dataset that is more representative of the Great Lakes Basin population.

Recommendation #3: That the two parties establish a cooperative data management system for human health and environmental exposure for the Great Lakes Basin, providing access to data that is accessible to researchers and the general public.

This could be achieved by funding a reference to the IJC, or enhancing existing capacities within governments such as the IJC's Great Lakes Regional Office or the Great Lakes Observing System, to create a binational data centre. Such a centre would coordinate and collect health and exposure surveillance information relevant to the Great Lakes Basin in such a way as to permit ongoing monitoring, academic access for particular studies, and public access to the data where appropriate.

Recommendation #4: That governments improve the quality and usability of data by making funding proportional to the quality, accessibility and harmonizability of data collected in the Great Lakes. This should be done in conjunction with a basin-wide initiative to harmonize existing datasets and develop agreements on their joint transboundary use.

Recommendation #5: That the NHANES (National Health and Nutrition Examination Survey) and CHMS (Canadian Health Measures Survey) include an oversampling for the Great Lakes region that will allow comparisons to the rest of the two countries. This is necessary because neither survey is constructed to provide information on which health outcomes occur more or less often in the Great Lakes basin.

Recommendation #6: That the parties expand the suite of human health indicators that provide meaningful information on the state of human health related to the Great Lakes environment. Ideally these should move from the current exposure-based indicators into health outcome indicators. The indicators would then guide decisions about priority areas for better data collection and monitoring of human exposures and associated health impacts.

Recommendation #7: Biomonitoring resources should be focused on two vulnerable sub populations: Young children and pregnant women. Health assessments need to accompany biomonitoring information to make it useful for understanding exposure-health associations.

Recommendation #8: First Nations and Tribal populations have distinct needs for environmental health (for example, vulnerability to water quality problems) and should be considered high priority for environmental and health surveillance.

2 Introduction

2.1 Objectives

Under the Great Lakes Water Quality Agreement, the Canadian and United States governments are required to provide for safe drinking water, fish consumption, and recreational water use in the Great Lakes. The aim of this report is to provide advice to the governments on how to address the growing need for integrated environmental-human health surveillance data in the Great Lakes Basin. Integrated data will enable decision makers to make more informed protection and restoration decisions related to ecosystems and public health in the Great Lakes. To accomplish this, the report has the following specific objectives:

1. To identify and evaluate successful integration of human health and environmental exposure databases used to study environment-linked illness in the Great Lakes Basin through a review of the current literature.
2. To provide a qualitative inventory of available databases for the Great Lakes Basin relevant to human health or to environmental exposures.
3. To summarize the challenges in integrating existing Great Lakes databases for the following purposes:
 - a. Surveillance of public health to determine cost-effective options for improving human health through prevention and remediation of environmental contamination.
 - b. Development of human health indicators for the Great Lakes to provide measurable evidence of improved ecosystem health, and preserve the unrestricted use of the Great Lakes as a resource for drinking water and edible fish as well as recreational activities.
 - c. Identify future research efforts to better establish associations between human health outcomes and environmental contamination.
4. To identify gaps in existing databases.
5. To propose recommendations for future work based on the findings of the report.

2.2 Background

The Great Lakes Basin encompasses the five Great Lakes (Lake Ontario, Lake Michigan, Lake Erie, Lake Huron, and Lake Superior) and shore lines in the States of Wisconsin, Minnesota, Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York, in the United States, and the Province of Ontario in Canada (Figure 1).

Figure 1 Map of the Great Lakes Basin



Source: Atlas of Canada

The Great Lakes Basin is heavily populated; about one-third of the Canadian population and one-tenth of the United States population reside in the Great Lakes Basin and rely on its water for household, industrial, agricultural, transportation and recreational uses (Environment Canada, 2007). Over the past 200 years, changes in the patterns of human activities, such as increased industrialization, large scale agricultural operations, urbanization and globalization both within and outside the Great Lakes Basin have placed tremendous pressure on the Great Lakes ecosystem (Johnson et al., 1999). Since the early 1960s, there has been notable evidence of increasing stressors on the Great Lakes ecosystem and the presence of hazardous, persistent substances in the Great Lakes water, air, sediments and wildlife

(Johnson et al., 1999). Some persistent chemicals, including polychlorinated biphenyls (PCBs) and dichloro-diphenyl-trichlorethane (DDT), have declined in the Great Lakes as a result of environmental restoration and regulation efforts (Chang et al., 2012; Crimmins et al., 2012; International Joint Commission, 2013). Since 1987, the levels of many persistent toxic chemicals entering the Great Lakes from atmospheric deposition have declined. Concentrations of most measured persistent toxic chemicals declined in herring gulls, fish, sediments, and mussels. Most reductions occurred from 1987-2000 (International Joint Commission, 2013). While trends since 2000 are less clear, a few recent studies that have shown a decreased level of polychlorinated biphenyls, Polybrominated diphenyl ethers (PBDEs) and organochlorine pesticides in Great Lakes fish (Chang et al., 2012; Crimmins et al., 2012). However, despite this decline in some chemicals, many still exceed human and ecological thresholds, and health problems are occurring at lower concentrations than expected (e.g. mercury). Additionally, concentrations of some chemicals of emerging concern have increased since 1987. For instance, polybrominated diphenyl ether (PBDEs, used as flame retardants) concentrations in fish doubled every few years from 1980 to 2000 and since then started to decline slightly (Zhu & Hites, 2004; Zhu & Hites, 2005).

This contamination of the Great Lakes ecosystem has been associated with body burdens of these toxic substances in consumers of Great Lakes fish and those who are exposed to the Great Lakes (through recreational and occupational activities) (Falk et al., 1999; Turyk et al., 2006). These body burdens, found in exposed populations' fluids and tissues, appear to be higher than those in the general population, particularly for PCBs, organochlorines and heavy metals like lead and mercury. Research studies that investigate the human health effects of these body burdens have found associations with several adverse human health impacts including neurobehavioural and reproductive (Buck et al., 2003; Jacobson et al., 1984; Weisskopf et al., 2005). Some populations are more vulnerable to these health impacts than others. For example, First Nations, tribes and Métis have lifestyles that are especially threatened because of their reliance on Great Lakes fish as a source of food and the waters as fundamental to their cultural values (International Joint Commission, 2013).

Significant pollution of the Great Lakes can expose the 35 million basin residents to serious health problems while imposing recreational restrictions and economic losses (International Joint Commission, 2013). To mitigate this, the Great Lakes Water Quality Agreement between Canada and the United States aims to restore and maintain the chemical, physical and biological integrity of the Great Lakes and includes several specific objectives to accomplish this (International Joint Commission, 2013). However,

one of the important challenges that environmental-health practitioners and policy-makers face is understanding the specific health impacts of the contamination of the Great Lakes Basin and their magnitude. A barrier to attaining this understanding is the lack of integrated environmental and human health currently collected surveillance data. This report provides a detailed discussion of the kinds of data that are already integrated, and the challenges and opportunities for integrating new datasets specific to the Great Lakes Basin.

2.3 Environmental Burden of Diseases

According to the World Health Organization's report "Preventing Disease through Healthy Environment: Towards an estimate of the environmental burden of diseases", approximately one-quarter of the global disease burden, such as prevalence of diarrhoea, lower respiratory infection, and malaria, are attributable to modifiable environmental factors, such as poor air quality and water and sanitation (World Health Organization, 2006). In Canada, air pollution costs the economy billions of dollars per year as a result of lost productivity and increased healthcare costs, and the loss of social welfare as a result of pain and suffering associated with the burden of illnesses (Environment Canada, 2010a). In a study conducted by Environment Canada's Great Lakes and Corporate Affairs Branch in 2001, the cumulative cost of environmental-related diseases such as diabetes, Parkinson's disease, neurodevelopment effects and hypothyroidism and lowered IQ was calculated at \$500-700 billion per year for Canada and the United States combined (Muir & Zegarac, 2001). While multiple factors may contribute to the development of these illnesses, the authors estimated that modifiable environmental factors account for 10-50% of these illness costs, or \$50-350 billion for the two countries (Muir & Zegarac, 2001).

In the United States, a study conducted by the Center for Children's Health and the Environment in 2002, estimated that environmental-related pediatric illnesses, such as lead poisoning, asthma, cancer and neurobehavioral disorders cost about \$54.9 billion per year and account for about 3% of total health care costs in the United States (Landrigan et al., 2002). In an updated study in 2008, the costs of illnesses associated with environmental exposure, such as lead poisoning, prenatal methylmercury exposure, childhood cancer, asthma, intellectual disability, autism, and attention deficit hyperactivity disorder had increased to about \$76.6 billion per year (Trasande & Liu, 2011). Given the social and economic costs associated with environmental burden of diseases, there is a need for policy makers, researchers and the public to develop a better understanding of the interrelationship between human health and

environmental exposures in the Great Lakes Ecosystem, and formulate public policy to reduce these costs.

2.4 Rationale for Integrating Environmental and Human Health Data

There are several benefits to integrating environmental and human health data. For example, when the etiology of a disease is unknown but environmental causes are hypothesized, linking human health and exposure data can facilitate studies that examine these potential associations (Kyle et al., 2006; Elliott et al., 2001; McGeehin, 2004). There are many examples of research studies that have integrated environmental and health datasets to examine the association between environmental exposures and human health outcomes. For example, in order to test the hypothesis that living near an area with persistent organic pollutants can increase exposure and subsequent risk of developing non-communicable diseases, such as heart diseases, stroke, and diabetes, researchers have linked hospitalization discharge rates with the concentration of persistent organic pollutants based on zip code in New York State (Sergeev & Carpenter, 2005; Sergeev & Carpenter, 2010a; Sergeev & Carpenter, 2010b; Sergeev & Carpenter, 2011; Kouznetsova et al., 2007). Similarly, researchers have integrated asthma emergency department visits/hospitalization discharge data with air pollution data (e.g. concentration of particulate matter) based on zip code/area code to assess the association between air quality and asthma episodes among adults and children in Canada and the US (Norris et al., 1999; Ma et al., 2007; Lin et al., 2002; Babin et al., 2007; Sheppard et al., 1999). In addition, researchers have linked maternal exposure to environmental hazards (e.g. consumption of PCB/methylmercury contaminated fish from the Great Lakes Basin) with reproductive outcomes data (e.g. low birth rates, decrements in gestation, birth defects) to examine the relationship between water pollution and its impact on maternal and fetal health (Witkowski et al., 1992; Buck et al., 2003; Swain, 1991; Karmaus et al., 2004; Karmaus et al., 2009; Weisskopf et al., 2005).

If the association between human health and the environment has already been established, linking environmental stressors, human exposure and human health outcome data can help policy makers monitor trends and identify opportunities for intervention (Kyle et al., 2006; McGeehin, 2004; Elliott et al., 2001). For example, in Oregon, based on the findings from the state-wide Environmental Public Health Tracking Program, the level of arsenic in more than 100 residential wells in the Sutherlin Valley was found to be higher than healthy drinking water standards (CDC, 2011a). Since long-term exposure to arsenic is known to have a negative impact on reproductive organs, the heart, skin and nervous

system, the state of Oregon passed legislation in 2009 to make testing arsenic in private wells mandatory, as a result of the study's findings (CDC, 2011a).

For health outcomes with multiple causative exposures, integrating environmental and human health data is valuable for identifying the magnitude and relative contribution of various exposures. For example, integrating datasets that include information about exposures to contaminants with datasets that have information about personal behavioural exposures (e.g. smoking), may provide information about the relative contributions of these exposures to an outcome like cancer.

Finally, linking ecosystem health data and human health data through environmental health indicators can also help inform the public about the potential environmental health concerns and allow them to take necessary precautions (Kyle et al., 2006). For example, the Florida Environmental Public Health Tracking Program found that women of child-bearing age in Duval and Martin counties consumed a large amount of fish and had a high level of mercury in the hair (CDC, 2011b). In response to the study findings, Florida public health distributed wallet cards with information on the mercury content in different species of fish and the suggested weekly fish intake at fish markets and grocery stores to help women living in these communities take precautionary measures in consuming unsafe amounts of mercury (CDC, 2011b).

In conclusion, there are several important reasons for the integration of environmental and human health data. However, one of the key challenges is identifying available data that is most suitable and feasible for integration. The following sections of the report will provide details on the process and research findings from the literature and database search conducted.

3 International Joint Commission Integration of Great Lakes Basin Human Health-Environmental Surveillance Project

In order to address the growing need for integrated environmental-human health surveillance data in the Great Lakes Basin, in 2012, the International Joint Commission's Health Professional Advisory Board (IJC HPAB) initiated the Great Lakes Basin Environmental-Human Health Surveillance Integration project. The purpose of this project is to review the current literature that provides successful examples of this

kind of integration, describe the existing databases for the Great Lakes Basin relevant to human health or to environmental exposures, summarize the opportunities and challenges in integrating these data, and propose recommendations for future work related to the findings of this report. These recommendations will be submitted to the IJC commissioners for consideration. The overall goal of this work is to use these data to improve the ability of government agencies, academics and the public to identify population health trends that are associated with the environmental changes in the Great Lakes Basin. This analysis was conducted as part of Phase 1 activities for the Integrating Ecosystem & Human Health Surveillance Data Project, under the priority for Capacity to Deliver Great Lakes Science & Information.

3.1 Methodology

Data Sources:

The information regarding environmental exposure and human health surveillance data was collected through a literature review and series of expert consultations.

1. Literature

In order to review specific research datasets relevant to the Great Lakes area and to examine pre-existing environmental health surveillance datasets in Canada and the United States, a comprehensive review was conducted. Two categories of literature were searched: peer-reviewed and grey literature.

Peer-Reviewed Literature

PubMed and ScienceDirect were used to identify peer-reviewed papers that included research using environmental and health datasets in the Great Lakes area. For each of the research studies, the research question, type and size of the dataset and methods of collection were noted as part of the review process.

Grey Literature and Government Reports

In recognition of the fact that many datasets would not be captured in familiar, peer-reviewed literature but would be in less easily found sources from governmental and other organizations. Accordingly, the websites of the following key stakeholder groups and public entities involved in environmental and health surveillance activities were included in the search of grey literature:

Canada

- Statistics Canada
- Canadian Institute of Health Information
- Canadian Institutes of Health Research Institute for Clinical Evaluation Sciences
- Environment Canada
- Health Canada
- Public Health Agency of Canada
- Natural Resources Canada
- Ontario Ministry of Agriculture, Food and Rural Affairs Ontario Ministry of Health and Long-Term Care
- Ontario Ministry of Environment
- Ontario Ministry of Natural Resources
- Ontario Ministry of Northern Development and Mines
- Ontario Ministry of Transportation
- Public Health Ontario
- Fisheries and Oceans Canada

United States

- United States Centre for Disease Control
- United States Environmental Protection Agency
- United States Census Bureau
- United States Geological Survey
- United States Food and Drug Administration
- United States Department of Agriculture
- United States Government
- Agency for Toxic Substances and Disease Registry
- Michigan Department of Environmental Quality
- Michigan Department of Community Health
- Pennsylvania Department of Environmental Protection
- Pennsylvania Department of Conservation and Natural Resources
- Pennsylvania Department of Health
- Wisconsin Department of Agriculture, Trade and Consumer Protection
- Wisconsin Department of Natural Resources
- Wisconsin Department of Health Services
- Ohio Lake Management Society
- Ohio Department of Health
- Ohio Environmental Protection Agency
- Ohio Department of Natural Resources
- New York State Department of Environmental Conservation
- New York State Department of Health
- Indiana Department of Environmental Management
- Indiana State Department of Health
- Indiana Geological Survey
- Illinois State Water Survey
- Illinois Environmental Protection Agency
- Illinois Department of Public Health
- Minnesota Pollution Control Agency
- Minnesota Department of Health
- Minnesota Department of Natural Resources
- Minnesota Geological Survey
- California Department of Health Services
- California Environmental Protection Agency

For each key stakeholder group, information regarding ongoing monitoring/surveillance efforts in the Great Lakes, how the information is analyzed and used, and the coordinated efforts among the different stakeholders in the Great Lakes Region were noted as part of the review process.

Key Words Searches:

For both the grey and peer-reviewed literature, the following key words were used to identify relevant environmental –health data information in the Great Lakes area:

- Great Lakes Basin
- Human Health
- Exposure
- Health outcomes
- Environmental stressors
- Environmental hazards
- Environment
- Datasets
- Water Quality
- Air Pollution
- Air Quality
- Waste Water
- Monitoring
- Surveillance
- Environmental Tracking
- Environmental Health Indicators
- Area of Concerns
- Public Health Tracking
- Survey
- Spatial
- Integration
- Water Quality
- Toxic
- Toxins
- Exposure
- Health outcomes
- Harmful Algal Bloom
- Run-offs
- Farm Management
- Hazardous Waste
- Nutrients
- Sediment
- Contamination
- Biomonitoring
- Vulnerable Population
- Aboriginal
- Tribal
- Children
- Maternal Health
- Pregnant women
- Fetus
- Diet
- Fish consumption
- Surface water
- Ground water
- Stream
- River
- Lakes
- Wetlands
- Drinking water
- Wells
- Sport Fish
- Discharge
- Lake Ontario
- Lake Superior
- Lake Michigan
- Lake Huron
- Lake Erie

2. Expert consultations:

A series of consultations with environmental health surveillance experts and Great Lakes researchers in Canada and the United States was conducted in January and February 2013 to examine the opportunities and challenges for integrating environmental-human health data in the

Great Lakes Basin. Over a four-week period, interviews with experts were conducted through a combination of in-person meetings, 30-60 minutes conference calls and/or e-mail correspondence. A set of interview questions was prepared to elicit information from experts regarding existing environmental and health datasets and challenges, opportunities and barriers to integration. The interview questions were modified accordingly based on the expertise of the interviewee. The interview question template used for the expert consultations and the contact information and affiliation of the experts can be found in Appendix B.

Analysis

The findings from the literature review and expert consultations were analyzed as follows:

1. Literature Review:

A descriptive analysis was conducted to describe the existing environmental exposure and human health datasets for the Great Lakes Basin that were found in the literature. These findings are described in the Great Lakes Environmental-Human Health Surveillance Inventory (Appendix A). For each dataset, the inventory includes the organization responsible for managing/collecting the data, geographical coverage and jurisdiction. As a first step, the datasets were identified with the aim of providing a comprehensive list of relevant sources of environmental and health data. Datasets were organized according to the type of data collected including: environmental stressors, environmental hazards, human exposure and human health outcomes. The detailed description of the four environmental-human health surveillance data types can be found in Table 1. Demographic and spatial datasets were also included given their relevance to environmental health associations.

An assessment of the inventory was conducted to highlight some of the key characteristics of existing environmental and health surveillance datasets in the Great Lakes area, including data availability, accessibility and emphasis on the needs of the vulnerable populations in the Great Lakes Basin.

2. Expert Consultations:

Common themes from the expert consultation interviews were extracted to capture common viewpoints and experiences related to data collection and use, data gaps, and other challenges with any aspect of integrating environmental and health data.

Table 1 Types of Environmental and Health Datasets

Data Type	Description
<p>Environmental Stressors</p>	<p>Environmental stressors are defined as any physical, chemical, or biological entity that can cause an adverse impact on some environmental resource that is worth protecting (US EPA 2008). Since our focus is on human health we are most concerned with chemical types of stressors (e.g. industrial run-off, waste water, nutrients run off, pathogens, trans boundary air pollution) within and outside the Great Lakes Basin.</p>
<p>Environmental Hazards</p>	<p>Environmental hazard data describes harmful substances that persist or are temporally in the Great Lakes ecosystem (e.g. water quality, air quality, soil/land quality and concentration of toxins in fish/biota).</p>
<p>Human Exposure</p>	<p>Human exposure data describe the extent to which an individual may encounter environmental hazards through ingestion, inhalation, dermal exposure, or other pathways. Ideally, human exposure data are collected through biomonitoring surveillance and direct measurement of exposures. However, where biomonitoring data is not available, the risk of human exposure to contaminants can be estimated by examining potential pathways of exposure and duration/quantity of exposure (e.g. inhaled for 8 hours, fish consumption, and drinking water) (Mather et al, 2004).</p>
<p>Human Health Outcomes</p>	<p>Human health outcome data describe the burden of illnesses in a population, which includes mortality, morbidity as well as quality of life measures such as Quality Adjusted Life Year (QALY) and Disability Adjusted Life Year (DALY). Furthermore, measures of health care utilization, such as cause-specific visits, medication specific prescription, emergency room visits can be used to assess the health of the population. The focus here is on human health outcomes considered to be related to potential or known environmental exposures in the Great Lakes Basin, such as birth defects and neurological impairment due to ingestion of contaminated Great Lakes fish.</p>

3. Environmental-Human Health Integration Framework:

Based on the information collected from the expert consultations and literature review, an analysis was conducted to systematically identify the underlying factors that affect environmental-human health data integration in the Great Lakes Basin. A framework was developed to describe the interrelationships and underlying factors that affect environmental-human health surveillance integration in the Great Lakes Basin.

4. Gap Analysis :

Using the Environment-Human Health Integration Framework, an analysis was conducted to identify the data gaps and limitations of the existing environmental-human health datasets in the Great Lakes Basin.

5. Case Studies

Ideas for case studies were suggested and have been highlighted as areas for further development to demonstrate how environmental exposure and human health outcome data can be applied in the context of emerging concerns in the Great Lakes area.

6. Recommendations

A set of recommendations was developed to guide future initiatives related to the integration of environmental-human health datasets in the Great Lakes area.

4 Objective 1: Existing Environmental-Human Health Surveillance Initiatives

There are several examples of the successful integration of environmental and human health data that range from large national programs to smaller local research studies. Many of these were initiated following the publication of the landmark Pew Environmental Health Commission report 'America's Environmental Health Gap: Why the Country Needs a Nationwide Health Tracking System', which highlighted the environmental health data gaps in the United States and recommended the development of a nation-wide environmental health tracking network (Pew Environmental Health Commission, 2000). In response to these recommendations, the Centers for Diseases Control and Prevention (CDC) initiated the development of the National Environmental Public Health Tracking program to facilitate the integration and dissemination of environmental hazard, human exposure and

health outcomes surveillance data across the United States (CDC, 2006). Internationally, the World Health Organization's Regional Office for Europe has also developed a similar environmental public health tracking system to integrate environmental and health data across the European Union (WHO Regional Office for Europe, 2005).

While Canada does not currently have a national environmental health tracking program, there have been efforts by government health and environmental agencies that indicate interest in developing environmental-human health surveillance datasets and capacity (Abelsohn et al., 2009; Statistics Canada, 2008). In 2001, the Federal/Provincial/Territorial Environmental and Occupational Health Surveillance Working Group in Canada commissioned a comprehensive needs assessment that examined the availability of environmental and occupational health surveillance datasets in Canada. Through the assessment, the Working Group identified the need to strengthen environmental and occupational surveillance capacity in Canada and to develop an environmental and occupational surveillance dataset inventory in Canada (Health Canada, 2004). In response to the Working Group's recommendation, Health Canada compiled an inventory of federal, provincial and territorial environmental and occupational health datasets in 2004 (Health Canada, 2004). Similarly, the First Nations Environmental Health Innovation Network also developed an inventory of environmental-human health datasets related to the First Nations communities in Canada (First Nations Environmental Health Innovation Network, 2007). Statistics Canada also convened an environmental-human health expert panel to identify potential opportunities to use national statistics to link human health and the environment (Statistics Canada, 2008).

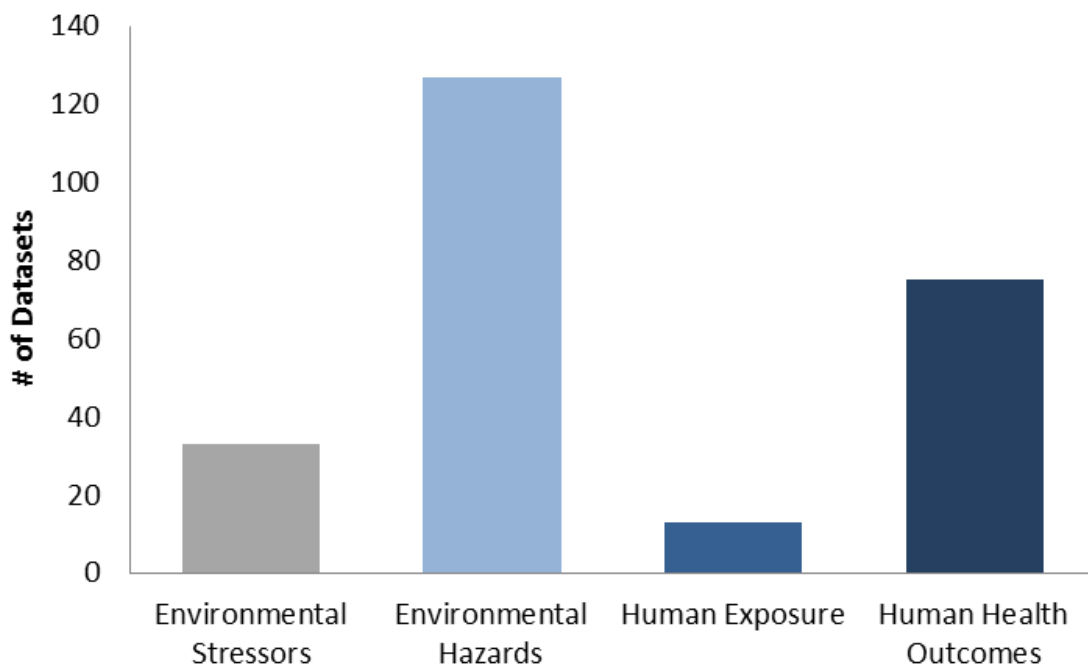
An example of binational work to develop a better understanding of some environment-human health concerns outside the Great Lakes Basin is occurring in the Salish Sea region (formerly known as the Georgia Basin-Puget Sound Region). Three universities in the region, the University of British Columbia, University of Victoria and the University of Washington have been collaborating on a series of research projects to examine the linkages between exposure to air pollutants and asthma, birth outcomes, bronchiolitis, and adult cardiovascular diseases as part of the Border Air Quality Study (University of British Columbia, 2008). Through detailed mapping, modelling and validation studies, and life course epidemiological studies of vulnerable populations, the study hopes to facilitate the development of a policy strategy for this large airshed (University of British Columbia, 2008). The most recent report on this region detailed the status of ten environmental indicators that are being tracked. These include

measures important to human health, such as air quality, freshwater quality, and swimming beaches (EPA, 2013).

5 Objective 2: Description of Environmental and Health Datasets

Over 250 health and environmental datasets relevant to the Great Lakes Basin were retrieved and reviewed in the search. A detailed overview of each dataset can be found in Appendix A. Figure 2 shows the total number of datasets reviewed for each of the data types: environmental stressors, environmental hazards, human exposure and human health outcomes.

Figure 2: Distribution of Existing Datasets (Reviewed) by Types



5.1 Environmental Hazards

Overview

The highest proportions of datasets were found in the “environmental hazards” category, which captured approximately half of all the datasets retrieved (n=127). These include data about hazards to drinking water, ground water, well water, surface water, and stream, soil quality, fish/biota

contamination, harmful algae blooms, food recalls, and smoke density, at both the national and regional level. National and provincial/state-wide environmental agencies collect a large portion of environmental hazard datasets. In Ontario, the majority of environmental hazard data is managed by the Ontario Ministry of Environment (OMOE). Most of the environmental datasets are available on the OMOE website

http://www.ene.gov.on.ca/environment/en/resources/collection/data_downloads/index.htm.

At the national level, Environment Canada manages and collects a wide range of environmental hazards data. In the United States, the US EPA and state-level environmental agencies are responsible for the collection of environmental hazard data in their specific jurisdictions. However, in both countries universities, environmental associations, volunteer groups and communities may collect some environmental hazard data through community or volunteer-based monitoring programs or citizens' reports, such as Ontario Lake Partner Program's (LPP) data program (Ontario Ministry of the Environment, 2012). Given the vast landscape of the Great Lakes Basin, experts indicated that the effort required to conduct an extensive environmental hazard surveillance program would be very costly, time consuming and resource intensive. As such, environmental hazard data are typically collected at select monitoring locations and may not be collected on a regular basis. Most of the environmental hazard datasets in Canada and the United States can be made publically available upon request, and some are freely available on governmental websites.

Water Quality, Sediments Quality and Fish Contamination

In Canada, at the national level, Environment Canada monitors water quality through the Great Lakes Surveillance Program (Environment Canada, 2011a; Great Lakes Commission, 2006). Provincially, the OMOE's Environmental Monitoring and Reporting Branch manage the Great Lakes Nearshore Monitoring and Assessment Program (GLWQM). There are three key components to this program: (1) Nearshore Mapping, (2) Harbour Water Quality Monitoring and (3) Great Lakes Nearshore Index Station Network (Ontario Ministry of the Environment, 2004). Nearshore mapping is a survey that monitors the nutrient and bacteriological content of the water along the Great Lakes shoreline. The data collected from the nearshore mapping component of the program is used for mapping spatial patterns along the Great Lakes shoreline (Ontario Ministry of the Environment, 2004). The harbour water quality monitoring component of the program focuses the surveillance effort on locations with a high risk of environmental contamination. Finally, water and sediment quality are collected periodically at 66 index stations through the Great Lakes Nearshore Index Station Network (Ontario Ministry of the

Environment, 2004). In addition to monitoring the water quality of the Great Lakes Basin, the OMOE also manages the Ontario Sport Fish Contaminant Monitoring Program. This program collects fish samples from Lake Ontario and assesses for contaminants, such as PCB, mercury, mirex, DDT, and dioxins/furans (Great Lakes Commission, 2006).

In the United States, most of the environmental hazard data related to water quality in the Great Lakes Basin can be accessed through the EPA Great Lakes National Program Office's Great Lakes Environmental Database (GLENDa) (U.S. EPA, 2012a). The GLENDa database provides access to water, biota, sediments and air data related to the Great Lakes Basin, including water chemistry, fish tissue chemical, fish sample, and sediment chemistry data (U.S. EPA, 2012a). GLENDa can be accessed through the EPA's Central Data Exchange system upon registration (U.S. EPA, 2012a).

The Great Lakes Observing System (GLOS) is an example of a regional, centralized platform that facilitates the collection and integration of Great Lakes water quality data (Integrated Ocean Observing System, 2008). By connecting data users with data suppliers GLOS supports decision-making in four key areas relevant to the Great Lakes- Ecosystem Health, Public Health and Water Security, Maritime Operations, and Climate Change and Natural Hazards.

In terms of fish contaminants in the US, the Great Lakes Fish Monitoring program includes two programming streams: Open Lake Trend Monitoring Program and Emerging Chemical Surveillance Program (U.S. EPA, 2012b). The Open Lake Trend Monitoring Program was first developed in the late 1970s to track contaminants and monitor the impact of toxins in fish in open water of the Great Lakes (U.S. EPA, 2012b). The Emerging Chemical Surveillance Program helps inform the Open Lake Trend Monitoring program by screening for emerging chemicals in fish tissues (U.S. EPA, 2012b). Water quality and fish contamination data are also collected at the state-level environmental and natural resource management agencies. However, the type of data collected varies across the different states depending on the specific surveillance needs and resource availability.

The Chemical Management Plan (CMP) was launched in 2006 to strengthen efforts to protect Canadians from exposure to harmful chemicals in the environment (Environment Canada, 2011b). Under the CMP, the Government of Canada provides funding to support research and monitoring of environmental hazards (i.e. chemicals found in air, water, sediment, non-human biota (fish and wildlife), environmental hazards monitoring (e.g. wastewater treatment plant effluents and sludge; landfill leachate and biogas) as well as human health surveys and contaminant biomonitoring (Environment Canada, 2011b). For

example, the Canadian Health Measures Survey, a major national biomonitoring program, was established under the CMP (Environment Canada, 2011b).

Air Quality

The Integrated Atmospheric Deposition Network (IADN) is the only air quality monitoring program that specifically focuses on the Great Lakes Basin (U.S. EPA, 2012c; Great Lakes Commission, 2006). The IADN is a joint U.S. EPA and Environment Canada air quality monitoring network that collects information about the wet and dry deposition of semivolatile organic compounds (SVOCs) and traces of metals in the Great Lakes Basin (U.S. EPA, 2012c). Each lake has a master station, which measures the complete set of IADN chemicals (U.S. EPA, 2012c). Associated satellite stations are located throughout the Great Lakes Basin to improve the geographical representation of the datasets (U.S. EPA, 2012c).

In addition to the IADN, Environment Canada's National Air Pollution Surveillance (NAPS) Network and the Canadian Air and Precipitation Monitoring Network (CAPMON) are the two key air pollution monitoring programs in Canada. NAPS monitors concentrations of sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone and total suspended particulates in selected cities across Canada (Environment Canada, 2013). CAPMON collects atmospheric pollutant data in air and precipitation at selected sites across Canada (Environment Canada, 2010b). In addition to NAPS and CAPMON, the OMOE also tracks air quality at various monitoring locations across the province through the Ambient Air Monitoring program (Great Lakes Commission, 2006; Ontario Ministry of the Environment, 2010). The data from NAPS and CAPMON are publically available and can be accessed online.

In the United States, EPA's Air Quality System (AQS) tracks both criteria air pollutants and hazardous air pollutant released across the United States (U.S. EPA, 2012d; Great Lakes Commission, 2006). Ambient air quality is also measured by ambient air quality monitoring networks that are managed by state level environmental agencies. However, the type of data collected at the state level air monitoring network varies across the different states (Great Lakes Commission, 2006). Additionally, air monitoring stations may not represent actual air quality at very fine spatial scales as the data depends largely on their location and therefore may only be a proxy measure for areas further away.

5.2 Human Health Outcomes

The next largest dataset category captures information about human health outcomes (n=75). A wide range of health outcome data is collected in both Canada and the United States. While there are not

many datasets specific to Great Lakes, most of the existing health outcome data are linked to small geographic units/subdivisions (e.g., census tracts, counties, electoral areas) and some of these datasets can be scaled to be representative of the health status of the population. There is still a lot of work to be done to understand in detail which contaminants are pervasive and which occur locally and sporadically. Some of the challenges about the scientific uncertainty are discussed in more detail in this section and include access to the data, lack of a centralized database for the many datasets, and a lack of data in general.

Traditionally, health outcome data typically include hospital admissions, hospital discharge, diseases registries (e.g. cancer registries), vital statistics, health insurance claims, emergency department visits and data collected through community health interviews or surveys. While human health outcome data are largely captured by administrative databases in both Canada and the United States, in some cases sample surveys may be used to supplement the administrative data, for example Statistics Canada's Aboriginal People Survey (www.statcan.gc.ca/aps). In addition to the traditional indicator-based surveillance, event-based surveillance can also be used as a key source of health outcome data. In particular, there has been a growing interest in using novel surveillance streams and approaches, such as on-line cohorts, 'crowd-sourcing', tele-health data, electronic health records, and syndromic surveillance to monitor the changes and trend in the health of the population (<http://www.cdc.gov/ehrmeaningfuluse/syndromic.html>).

While the characteristics and structure of health outcome data are generally well-suited for integration with environmental data, these data are not easily accessible to the public or to researchers (Love et al., 2008). Aggregated health outcome data are more easily available, while record-level health data typically require ethical and data sharing agreements, and in many cases must be accessed only at secured locations, such as the Research Data Centres of Statistics Canada (United States Department of Health and Human Services, 2007; Canadian Institutes of Health Research, 2006). In the absence of authorization and consent from the individuals, most of the record-level health outcome data accessible by researchers are de-identified (i.e. direct identifiers, such as names, postal code, account numbers are removed from health data) in order to respect privacy and confidentiality. The extent to which health records are de-identified will depend on privacy and confidentiality policies and legislations enforced by the different jurisdictions (United States Department of Health and Human Services, 2007; Canadian Institutes of Health Research, 2006).

Canada Data Sets

In Canada, health outcome data are collected at the health unit, community, and provincial/territorial levels by national, provincial and local health agencies. Under the Ontario Public Health Standards Environmental Health program, local health agencies are required to collect and report data related to food safety, water safety and health hazards (Ontario Ministry of Health and Long Term Care, 2008a). Specifically, local health agencies are required to conduct surveillance and monitoring of food-borne illnesses, drinking-water systems, public beaches, associated water illnesses, and the environmental health status of the community (e.g. health risks associated with indoor/outdoor air quality, extreme weather, climate change, exposure to radiation) within their local health units. Although the Ontario Public Health standards provide a series of documents to guide these monitoring and surveillance activities, there are no strict requirements that dictate how these monitoring and surveillances activities should be carried out (e.g. a consistent set of parameters collected or frequency of data collection) (Ontario Ministry of Health and Long Term Care, 2008a; Ontario Ministry of Health and Long Term Care, 2008b; Ontario Ministry of Health and Long Term Care, 2008c; Ontario Ministry of Health and Long Term Care, 2008d; Ontario Ministry of Health and Long Term Care, 2009; Ontario Ministry of Health and Long Term Care, 2010a; Ontario Ministry of Health and Long Term Care, 2010b). Given the varying needs and resource capacities of the local health units in Ontario, the existing health outcome data collected by health units have varying data structures and temporal/spatial scopes. These data are not stored in a centralized location across the province and are published on a program by program basis. The accessibility of these datasets may vary across the different local health units.

At the provincial level, the Institute for Clinical Evaluative Sciences (ICES) is the key organization that is responsible for managing health outcome data in Ontario. ICES holds a wide range of health service data information as well as disease cohort and registry data including the Ontario Health Insurance Plan Claims database, Discharge Abstract Database, Ontario Drug Benefit Claims, National Ambulatory Care Reporting System, Cardiac Care Network Data, Ontario Diabetes Database, Ontario Cancer Registry, Registry of Canadian Stroke Network and datasets linking admission records of mothers and their newborns to respect privacy and confidentiality of health information, ICES data can be linked anonymously through a combination of patient identifiers, physician identifiers, dates, and service codes using unique ICES identifiers (ICES, 2011a). However, to access ICES data, researchers need to partner with an ICES scientist or become an ICES scientist. As well, researchers can only access and use the data at the ICES main office or at the ICES satellite sites (ICES, 2011b).

Much of the national health outcome data are housed at the Canadian Institute of Health Information (CIHI). Similar to ICES, CIHI holds a wide range of national health services data information, disease cohort and registries data, including the Hospital Morbidity Database, National Ambulatory Care Reporting System, Primary Health Reporting System and Discharge Abstract Database (DAD). Some of the aggregated datasets are publically available online through the CIHI website (CIHI, 2013a). A system of application and approvals is required to access detailed and customized datasets at CIHI (CIHI, 2013b). As a cost-recovery measure, there's a fee associated with any customized data requests from CIHI (CIHI, 2013b). Unlike ICES, data can be removed from CIHI and analyzed by a researcher using their own facilities. Similar administrative and registry data can be found through Statistics Canada. Vital Statistics is an administrative database that collects provincial and territorial vital statistics on all live births, stillbirths and causes of deaths in Canada (Statistics Canada, 2012a; Statistics Canada, 2012b; Statistics Canada, 2012c). The Canadian Cancer Registry (CCR) is a nation-wide administrative database that manages and stores cancer incidence data from provincial and territorial registries, such as the Ontario Cancer Registry (Statistics Canada, 2012d).

Statistics Canada is also responsible for several population health surveys that collect important health outcome and exposure data. The Canadian Community Health Survey (CCHS) is a cross-sectional survey that collects data related to health status, health care utilization and health determinants of Canadians at the national, provincial and provincial health region level (Statistics Canada, 2012e; Health Canada, 2012). Since 2007, CCHS data are collected on an ongoing basis (12 two-month collection periods) and are released on an annual basis. A second survey, the National Population Health Survey (NPHS), is a longitudinal survey that is conducted every two years to gather information about healthcare utilization, health and socioeconomic information of the Canadian population. The NPHS was conducted over 9 survey cycles from 1992-2012 (Statistics Canada, 2012f). Although the NPHS initially included both a cross-sectional and longitudinal component, the cross-sectional component of NPHS became part of the CCHS in 2000 and NPHS became strictly a longitudinal survey in 2000 (Statistics Canada, 2000; Statistics Canada, 2012f). Similar to other health outcome data, most of the aggregated health outcome data at Statistics Canada are available either through Statistics Canada's Canadian Socio-Economic Information Management System (CANSIM) or online. De-identified, record-level data can only be accessed upon request through Statistics Canada's Research Data Centres and through data sharing agreements (Statistics Canada, 2013a).

United States Data Sets

In the United States, health outcome data are collected at the local, state and national level. Most of the state level public health agencies are responsible for collecting public health surveillance data. However, due to varying surveillance needs and resource capacity, the type of data collected by each state can vary greatly.

At the US national level, the CDC's National Center for Health Statistics (NCHS) is one of the main repositories of health outcome data. The NCHS collects health outcome data primarily through the National Health Interview Survey (NHIS) and the National Vital Statistics System (NVSS). The NHIS collects health outcome data through personal household interviews on an annual basis (CDC, 2012a). All NHIS datasets at the census level can be accessed online at no charge. However, record-level data for restricted variables can only be accessed upon request through the NCHS's Research Data Centre (CDC, 2011c). Just like Statistics Canada, the NCHS is also responsible for managing the National Vital Statistics System (NVSS) in the United States. NVSS is an administrative database that collects birth, mortality, fetal death, infant death, marriage and divorce data in the United States (CDC, 2012b). A set of aggregated data can be accessed publicly online at no charge. However, de-identified record-level data and customized microdata file can be accessed upon request (CDC, 2011d).

In addition to NCHS, the CDC also collects a wide range of data related to the burden of chronic illness through the National Center for Chronic Disease Prevention and Health Promotion (CDC, 2012c). The National Center for Chronic Disease Prevention and Health Promotion holds a wide range of health outcome surveillance data including the National Diabetes Surveillance System, the National Program of Cancer Registries, the Pediatric and Pregnancy Nutrition Surveillance System, and United States Cancer Statistics (USCS) (CDC, 2012d). Most of these aggregated health outcome data are publically available online. To access de-identified record level data in the cancer registries, researchers must follow an approval process and comply with the state and registry specific data access policies (CDC, 2012c). The CDC also collects a wide range of nation-wide health care services data through the National Hospital Discharge Survey, the National Hospital Care Survey, and the National Hospital Ambulatory Medical Care Survey (CDC, 2012e).

Finally, the Joint Canada/United States Survey of Health is a one-time joint population health survey conducted by Statistics Canada and CDC's National Centre for Health Statistics (Statistics Canada, 2007; CDC, 2009a). Data related to health status, health care utilization and health behaviours were collected

through a series of randomized telephone interviews with 3500 Canadians and 5200 United States residents between 2002 and 2003. The Joint Canada/United States Survey of Health aggregated and de-identified public use microdata files can be accessed directly online on the Statistics Canada and CDC websites (Statistics Canada, 2007; CDC, 2009a).

5.3 Environmental Stressors

Environmental stressors are defined as any physical, chemical, or biological entity that can cause an adverse impact on some environmental resource that is worth protecting (US EPA 2008). Since our focus is on human health we are most concerned with particular types of stressors (e.g. industrial run-off, waste water, nutrients run off, transboundary air pollution) within and outside the Great Lakes Basin. Relatively few datasets were found in this category (n=34).

Point Sources

As a result of the strict environmental regulations placed on hazardous substances, hazardous substances released by industrial facilities, such as mercury discharge, are well documented in Canada and the United States. Today, industries in Canada and the United States are required to report their discharge and emission as part of their operations if they exceed the maximum regulatory thresholds. As such, large stationary environmental stressors caused by industries, are likely to be collected on a regular basis through administrative processes. However, the type of environmental stressors data collected, the frequency of data collection, the location of data collection, and the collection methods are dictated by reporting requirements within each of the jurisdiction. In Canada, the National Pollutant Release Inventory (NPRI) is a legislated inventory that tracks pollutant releases, and disposal reported by industrial facilities (Environment Canada, 2011c). The NPRI database is managed by Environment Canada and is publically available. In Canada, in accordance with the Canadian Environmental Protection Act, 1999, owners of waste or sewage sludge incineration, wood preservation, fuel terminal operations, municipal wastewater collection and/or treatment, or pit or quarry operations or facilities (>10 full – time employees) that produce one or more NPRI substances are required to submit report to the NPRI on an annual basis (Environment Canada, 2011c). Emission release data is also collected through the NPRI.

Similarly, the US Environmental Protection Agency (EPA) Toxic Release Inventory (TRI) is the key source of environmental stressors information in the United States. The TRI is a national database that contains

pollutant disposal and chemical releases data from over 23,000 industrial facilities across the United States (U.S. EPA, 2012e). Similar to Canada, manufacturing, metal and coal mining, electric utilities, commercial hazardous waste treatment and facilities that manufacture or use toxic chemical substances are required by law to report to the TRI on an annual basis (U.S. EPA, 2012f). In addition to the EPA's annual report on the status of TRI, record-level data can be accessed directly online through the EPA's Envirofacts system (U.S. EPA, 2012e).

Although environmental stressor data that pertain to the Great Lakes Basin can be extracted from national environmental stressor databases, such as the NPRI and TRI, based on the location of the facilities, the data collected through these two inventories are designed to meet the regulatory needs of the jurisdiction. As such, the datasets from TRI and NPRI have not been designed to meet specific environmental-human health surveillance needs in the Great Lakes Basin.

Non-Point Sources

Unlike the industrial sector, the reporting of environmental stressors from agricultural operations such as farm run-offs for animal waste and pesticides/fertilizer management is voluntary in Canada and the United States. As such, the reporting of environmental stressors from agricultural operations is conducted occasionally depending on the resources and programs available. To date, most of the environmental stressors data from agricultural operations are generally collected through standalone sample surveys and research studies, such as the Statistics Canada Farm Environmental Management Survey (FEMS) and Crop Protection Survey.

Small, mobile, and non-point sources may be severely unreported in both Canada and the US. Often, contaminants released from such diverse sources as residential septic systems, automobiles and trucks, and urban stream runoff cannot easily be tracked (Loague & Corwin, 2006). In the United States, non-point, and mobile emissions are tracked episodically by the National Emissions Inventory (NEI) (U.S. EPA, 2012g). In Ontario, data related to traffic volume, such as the Ontario Ministry of Transportation Provincial Highway Traffic Volume data, can be used to estimate emissions from automobile and trucks (Ontario Ministry of Transportation, 2012). However, while it may be possible to model the emission/pollutant releases from mobile and non-point sources, it is often challenging to develop a basin wide model given the small scale and dispersed releases from these sources.

In addition to small, non-point, mobile environmental stressors, it is important to note that while many contaminants have a short fate/transport profile and may only be important in select localities, other

contaminants may persist and can be transported only slowly over time (Loague & Corwin, 2006). Furthermore, given the large scale movement of contaminants, particularly for air hazards such as ozone, it is also important to take cross-boundary monitoring into consideration when monitoring or estimating non-point, mobile stressors in the Great Lakes Basin.

5.4 Human Exposure

Human exposure data describe the extent to which an individual may encounter environmental hazards through ingestion, inhalation, dermal exposure, or other pathways (McGeehin et al., 2004). This category represents the smallest number of datasets found in our search (n=13). These datasets can be broadly categorized into findings from biomonitoring studies, exposure estimates, and survey findings.

Biomonitoring

Biomonitoring studies measure the body burden of chemicals and toxins by taking physical measurements from blood, urine, or hair samples (Health Canada, 2007). While biomonitoring is often considered the “gold standard” for assessing exposure to contaminants, these studies are typically costly to conduct. Recently, practitioners and researchers in both Canada and United States have initiated biomonitoring studies at the national level. In Canada, through the Chemical Management Plan (CMP), Health Canada and various partnering agencies have been developing various biomonitoring studies across the country, including the Canadian Health Measure Survey (CHMS), Maternal-Infant Research on Environmental Chemicals (MIREC), and the First Nations Biomonitoring Initiative (Environment Canada, 2011b). The CHMS is a nation-wide survey that is conducted every two years and collects health outcome and human exposure data from the Canadian population through household interviews and direct physical measurements (Statistics Canada, 2012g). As part of the survey, a mobile examination centre collects blood and urine samples from participants to test for chronic/infectious disease as well as environmental exposures, such as pesticides and mercury, at 18 selected collection sites (Statistics Canada, 2012g). Of the 18 selected collection sites, 4 are located in Ontario. However, given the small catchment area of the selected collection sites the data collected from the CHMS cannot be used to represent or to estimate the Great Lakes Basin population’s level of exposure to environmental hazards. In addition, the survey locations change in each sampling cycle so longitudinal biomonitoring data is not available.

The MIREC study is a biomonitoring study conducted over 5 years that looks at the exposure of pregnant women and their infants to environmental hazards (Maternal-Infant Research on Environmental Chemicals, 2013). In order to test for potential exposure to environmental contaminants, samples of blood, urine, hair and human breast milk are collected from 2000 pregnant women (including samples from their babies' umbilical cord blood and first stool) in 10 Canadian cities (Maternal-Infant Research on Environmental Chemicals, 2013). While some of the participating cities are located within the Great Lakes Basin, similar to the CHMS, given the small catchment area of selected collection sites the data collected from the MIREC cannot be used to represent or to estimate the Great Lakes Basin population's level of exposure to environmental hazards.

In the United States, the National Health and Nutrition Examination Survey (NHANES) and the National Children Study (NCS) are the primary sources of biomonitoring and human exposure data. NHANES is a nation-wide survey that is conducted to gather health and nutritional status data from adults and children in the United States (CDC, 2012f). NHANES is conducted continuously but released every two years. As part of the NHANES, mobile centres collect blood samples from participants to test for chronic/infectious disease as well as environmental exposures, such as lead (CDC, 2012f). Similar to the CHMS, a potential issue with NHANES is its lack of geographic representation. There are 16 sites where data are collected each year and these sites are changed each year (CDC, 2012f). Though the data are gathered and weighted to give a demographically representative sample, the small number of sites means that there may be few sites in the United States portion of the Great Lakes in any two-year period. Nor can the data between time periods be compared if the goal is to understand changes in basin wide exposures. NHANES data cannot be used to assess local conditions, as the population in any one area is very small and most localities have never been visited. Finally, researchers would require special permission to access record-level data and can only use the data at a secured CDC Research Data Center.

Similar to the MIREC study in Canada, the NCS is a comprehensive research study that looks at the impact of the environment on children's health and development in the United States (National Children Study, 2012). As part of NCS, information about the women's pregnancy, such as their diet, chemical exposure and environmental stress, is collected before the child is born (National Children Study, 2012). Once the child is born, researchers monitor the changes in the child's health status and development by conducting informal interviews and taking biologic samples from the child as well as ambient environmental samples on a periodic basis (National Children Study, 2012).

Exposure Estimates Datasets

The risk of human exposure to contaminants can also be estimated by examining the potential pathways of exposure and the duration/quantity of exposure (e.g. inhaled for 8 hours, fish consumption, and drinking water). The Canadian Total Diet Study (TDS) and the International Information System on Occupational Exposure to Carcinogens (CAREX) Canada project are examples of estimated exposure datasets in Canada. The Canadian TDS estimates Canadians' exposure to harmful chemicals through their diet by combining the concentration of contaminants in different food samples with average food intake data (Health Canada, 2009a). Since 1969, Health Canada has conducted the TDS on an occasional basis at various major cities across Canada. The latest study results are published on the Health Canada – Bureau of Chemical Safety website (<http://www.hc-sc.gc.ca/fn-an/surveill/total-diet/index-eng.php>).

CAREX Canada is a nation-wide surveillance project that estimates Canadians' exposure to carcinogens in the workplace and community environment at the national and provincial level (CAREX Canada, 2013). The CAREX project provides information about the type of carcinogens people are exposed to, the location and the extent of exposure (CAREX Canada, 2013). The profiles and estimates of environmental exposures for different carcinogens in the workplace and community can be accessed online through the CAREX websites (CAREX Canada, 2013). Similar to the MIREC and CHMS, the TDS and CAREX projects lack geographic representativeness and cannot be used to estimate the Great Lakes Basin population's level of exposure to environmental hazards.

In the United States the CDC manages the Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is a large state-based telephone cross-sectional survey that collects standardized information on health risk behaviours, preventative practices and health care access (CDC, 2008a). Since exposure data can be established by integrating environmental hazard data and human health behaviours, the BRFSS has been used to track exposure related behaviour in some states (Laflamme & Vanderslice, 2004; CDC, 2008b). California and Minnesota have used the BRFSS data to estimate potential exposure to lead, asbestos, radon and well water contamination among children and adults (CDC, 2008b). Other states, such as Florida, New York and Utah have used BRFSS information to assess potential exposure to environmental tobacco smoke (CDC, 2008b). Specifically, CDC has linked BRFSS data with environmental data, such as the EPA's 2001-2006 Air Quality System dataset, to assess the potential relationship between environmental pollutants with chronic diseases such as asthma, and cardiovascular health problems (CDC, 2008c). Information in the BRFSS is updated on a monthly basis (CDC, 2008d). State, county and city level data are publically available online (CDC, 2011e; CDC, 2011f). Researchers can only access data

at the zip code level after applying to each individual state and complying with each state's access guidelines.

The United States Food and Drug Administration (FDA) conduct the nation-wide Total Diet Study (TDS) to estimate United States residents' exposure to harmful chemicals through their diet. Four times each year, the FDA collects food samples from 12 different cities across the United States and monitors them for contaminants, such as pesticides residues, industrial chemicals and toxic elements (FDA, 2009). The concentration of contaminants found in the different food samples are combined with the results from national consumption survey data to estimate the potential exposure to chemicals for different age-groups (FDA, 2009). The latest study results are published on the FDA website (<http://www.fda.gov/Food/FoodScienceResearch/TotalDietStudy/ucm184232.htm>). Like the TDS in Canada, the US TDS lacks geographic representativeness and cannot be used to estimate the level of exposure to environmental hazards in the Great Lakes Basin.

Great Lakes Basin Exposure Studies

Most of the human exposure and biomonitoring programs in Canada and the United States are conducted at a national level and are not tailored to the specific needs of provinces, states, and Great Lakes area. To date, aside from a few standalone research studies, the National Human Exposure Assessment Survey (NHEXAS) Phase 1 field study and the Contaminants in Human Tissues Survey are the two key human exposure datasets that are representative of the population in the Great Lakes Basin. NHEXAS is a program designed to help researchers develop a better understanding of the relationship between human exposure to multiple chemicals at the community and regional level (U.S. EPA, 2012h; U.S. EPA, 2005). As part of the NHEXAS Phase 1 demonstration project, blood and urine samples from 250 residents in the Great Lakes area were tested for potential environmental contaminants, including volatile organic compounds (VOCs), pesticides, metals and polyaromatic hydrocarbons (U.S. EPA, 2012h; U.S. EPA, 2005; Clayton et al., 2002). The results from the field study were used to estimate human exposure to environmental contaminants in the Great Lakes area. Aggregated data from the NHEXAS phase 1 field study have been published in various journal publications (Clayton et al., 2002; Clayton et al., 1999; Thomas et al., 1999; Pellizzari et al., 1999).

The Contaminant in Human Tissue survey collected blood, serum and hair samples from self-selected participants living in 26 Great Lakes First Nations communities (Davies, 2001). To complement the biomonitoring study, participants were required to complete a survey about their consumption patterns

of fresh fish and wild games at the time of the study (Davies, 2001). The Contaminant in Human Tissue program was a key component of an environmental health research project, known as the Effects on Aboriginals from the Great Lakes Environment (EAGLE) Project that was targeted at the Great Lakes Aboriginal population (Davies, 2001; Chiefs of Ontario, 2012). While record level data from the study are not publically available, the aggregated data from the Contaminant in Human Tissue survey can be accessed through EAGLE project related publications (Davies, 2001; Chiefs of Ontario, 2012).

Great Lakes Health Research Studies

While environmental and health data relevant to the Great Lakes Basin have not been well integrated more broadly, there are several examples of research studies that have been conducted in the region that integrated these data for specific health outcomes. Many studies have focused on reproductive outcomes, for example, linking maternal exposures to contaminants in Great Lakes fish with adverse birth outcomes. Decreased birth weight has been the most frequently cited association (Buck et al., 2003; Karmaus et al., 2004; Weisskopf et al., 2005). A couple of cohort studies have been conducted with a focus on maternal and infant health and include the Michigan Maternal and Infant Study (Fein et al., 1983), and the Wisconsin Maternal and Infant Study (Dar et al., 1992). Studies from the Michigan cohort have reported associations between fish consumption and low birth weight in addition to other adverse outcomes including decreased head circumference and earlier gestational age (Fein et al., 1983). Follow-up studies of these infants have reported neurobehavioural deficits including poorer motor reflex and neuromuscular functioning and depressed responsiveness (Jacobson et al., 1984). Conception delay has also been assessed in a handful of studies. The most frequently cited are from the New York State Angler Cohort, a prospective cohort of New York State registered sportsmen and fishermen (Buck et al., 2000; Buck et al., 1999; Buck et al., 1997). These studies have produced mixed results as to whether consumption of Great Lakes fish is related to an increased time-to-pregnancy and is a good example of an area that requires further data and investigation.

There are also a few research studies that focus on other health outcomes. An association between diabetes and DDE exposure from consuming contaminated fish has been suggested in a cohort of Great Lakes sports fish consumers (Turyk et al., 2006). Memory and learning impairments have been associated with sport fish consumption in Michigan in older adults (Schantz et al., 2001). An increased risk of uterine fibroids has been reported in women participating in the Great Lakes Fish Consumption Study (Lambertino et al., 2011).

While these existing studies have demonstrated the potential value of integrating environmental and health datasets in the Great Lakes Basin, given the wide range of environmental-human health concerns in the Great Lakes Basin, more work needs to be done to explore the feasibility and challenges of integrating environment and human health data in the Great Lakes area.

5.5 Miscellaneous

Availability of Great Lakes Basin Spatial and Demographic Data

In Canada and United States, demographic data are readily available through the population census. In Canada, census data is managed by Statistics Canada and in the United States, the United States Census Bureau manages all the census related information (Statistics Canada, 2013b; United States Census Bureau, 2013). With the growing interest in remote sensing and geospatial analysis, both countries also have a comprehensive set of spatial data, including land cover, elevation data, and administrative boundaries. For example, the Geobase is nation-wide spatial database that is managed by the Canadian Council on Geomatics (Canadian Council on Geomatics, 2013). Researchers can access national, provincial and territorial spatial data through Geobase at no cost or access restriction (Canadian Council on Geomatics, 2013). In the United States, various public and academic agencies manage spatial data. Aggregated historical census information from 1790-2011 and the associated Geographic Information Systems(GIS) compatible boundary files can be accessed through the National Historical Geographic information System (NHGIS) (Minnesota Population Center, 2010). Furthermore, the EPA's Geospatial Data Access Project provides downloadable geospatial data of facilities and sites that are subject to environmental regulations (U.S. EPA, 2012i). A wide range of federal geospatial datasets can be accessed through the United States Government's Geospatial One-Stop Portal (United States Government, 2013). For Great Lakes specific spatial data, researchers can access geospatial data, including boundaries, elevation, environment, biota distribution, transportation, facilities, structure, and bathymetry data relevant to the Great Lakes region through the Great Lakes Information Network and the National Oceanic and Atmospheric Administration (NOAA) (Great Lakes Information Network, 2012; National Oceanic and Atmospheric Administration, 2013a).

Vulnerable Populations in the Great Lakes Basin

Aboriginal/Tribal Populations

Many Aboriginal and Tribal communities rely on fish as an important source of nutrition and as a way to support traditional societies (Wheatley & Paradis, 2005). Due to the effect of bioaccumulation of toxins and contaminants in fisheries, Aboriginal and Tribal communities, who consume large quantities of fish from the Great Lakes Basin, may be at increased risk of exposure to environmental hazards, such as methylmercury, lead and polychlorinated biphenyl (Wheatley & Paradis, 2005).

The Statistics Canada's Aboriginal People Survey (APS) and the Health Canada's Hedgehog Environmental Reporting System (HERS) are the two key national environment-human surveillance datasets in Canada that focus on Aboriginal populations. APS is a nation-wide survey conducted every five years to collect education, employment, health, language, income, housing and mobility data about the Aboriginal population in Canada (Statistics Canada, 2012h). Aggregated data and publications related to APS can be accessed on the Statistics Canada website. Academic and government researchers can access record-level data through the Statistics Canada's Research Data Centre (secured location) at no cost.

HERS is a nation-wide database that collects environmental data on First Nations communities, including indoor and outdoor air quality, drinking water quality, other water quality, soil contaminants, food contaminants, housing conditions in First Nations communities, and sanitation in food establishments and public buildings. Data from HERS are not publically available and potential users must contact Health Canada directly for additional information (Health Canada, 2004).

The existing national biomonitoring studies, such as CHMS and MIREC, are designed to represent the Canadian population and currently do not account for First Nations on reserves and Inuit. In order to establish a set of baseline exposure data for the First Nations people living on reserve across Canada, Health Canada in partnership with the Assembly of First Nations is currently in the process of developing the First Nations Biomonitoring Initiative. Through the First Nations Biomonitoring initiative, First Nations participants living on reserve will be tested for exposure to environmental hazards, such as trace metals (lead, mercury, cadmium, etc.), pesticides, PCBs, bisphenol-A, and brominated flame retardants (Health Canada, 2013). Given that the First Nation Biomonitoring initiative is still in development, it is unclear whether the data collected through the program will be representative of Great Lakes Aboriginal population. While there have been other nation-wide health studies for the First

Nations population, such as First Nations Regional Longitudinal Health Survey, to date, the Contaminants in Human Tissues Survey is one of the few large scale datasets that specifically focus on the Aboriginal communities' exposure to environmental hazards in the Great Lakes region (Davies, 2001; First Nations Information Governance Centre, 2010).

In the United States, the EPA has developed a Tribal Environmental Health Research Program to fund a series of environmental-human health research studies related to Tribal communities (U.S. EPA, 2013a). To date, there is a lack of on-going environmental-human health surveillance data that focuses on the Tribal communities in the United States, in particularly in the Great Lakes Basin. Most of the health data related to Aboriginal populations living in the Great Lakes Basin are collected through standalone studies. For example, in 1996, the New York State Department of health conducted a study to look at polychlorinated biphenyl (PCB) and dichlorodiphenyl dichloroethylene (DDE) exposure and the body burden of PCB and DDE among the Mohawk population living in New York (Fitzgerald et al., 1996). As well, in 1997, a group of researchers from the Medical College of Wisconsin assessed the concentrations of blood and hair mercury and serum PCBs in an Ojibwa population (Gerstenberger et al., 1997). As a follow up to the 1997 study, in 2000, a similar group of researchers from University of Wisconsin conducted a study to measure and track the concentration of Polychlorinated Biphenyl Congener in a group of Ojibwa volunteers who consume Great Lakes fish on a regular basis (Gerstenberger et al., 2000; Dellinger, 2003; Dellinger, 2012).

Children, fetuses, and pregnant women

Children, fetuses and pregnant women have been identified as vulnerable sub-populations in the Great Lakes Basin that are at particular risk of exposure to environmental hazards (ATSDR, 2009). Several research studies have shown the negative impact environmental contaminants have on children/fetus's neurological development (Johnson et al., 1999). As such, the availability of environmental exposure and human health surveillance data associated with maternal, fetus and child health is an important part of environmental-human health surveillance in the Great Lakes Basin.

In Ontario, the Better Outcomes Registry & Network (BORN) Ontario Information Network is a centralized registry that collects maternal and child health data from prenatal screening, Niday perinatal (Public Health Agency of Canada, 2005a), midwifery and newborn screening programs across the province (Better Outcomes Registry & Network, 2013). At the national level, the Canadian Paediatric Surveillance Program (CPSP) monitors for high impact and rare childhood disorder in Canada using data

collected from research studies conducted by paediatricians and other medical professional across Canada (CPSP, 2013). In addition to these provincial-wide and national-wide databases, there's also the Canadian Healthy Infant Longitudinal Development (CHILD) Survey, which is a study conducted over a six-year period to examine the relationship between indoor environmental pollutant and the risk of allergy and asthma in infancy and early childhood in Canada (CHILD, 2012).

To date, the Maternal-Infant Research on Environmental Chemicals (MIREC) is the only national biomonitoring initiative in Canada that focuses specifically on children, fetus and pregnant women (MIREC, 2013). In addition, Health Canada has been conducting small-scale biomonitoring studies to target specific populations, such as young children and other vulnerable populations (Health Canada, 2009b). For example, in 2009, Health Canada conducted a two-year study to estimate children's exposure to contaminants using data obtained from the CHILD study as well as taking biologic samples (Health Canada, 2009b).

In the United States, there are several national maternal and infant health surveillance databases managed by the CDC. First, there's the Pregnancy Risk Assessment Monitoring System (PRAM), which is a survey that is conducted on an annual basis to collect population-based data on maternal attitudes and pregnancy experiences at the state-level (CDC, 2012g). Data collected through the PRAM program can be accessed by researchers through a data sharing agreement (CDC, 2012h). As well, CDC also manages two program-based surveillance systems that monitor for the nutritional status of low-income infants, children and women: Pediatric Nutrition Surveillance System (PedNSS) and Pregnancy Surveillance System (PNSS) (CDC, 2012i). While the PedNSS collects health information on low income children from birth to age 5, PNSS gathers health data on low income women across the United States (CDC, 2012i). For PedNSS and PNSS, aggregated data are publically available and can be accessed through the CDC's website (CDC, 2012i).

Similar to Canada, the National Vital Statistics System in the United States is also an important source of maternal, fetal and children's health data. To date, the National Children Study (NCS) is the only national biomonitoring initiative that studies children's exposure to environmental contaminants (NCS, 2012). In addition to these national databases, the National Maternal and Infant Health Survey (NMIHS) also collects data related to poor pregnancy outcomes, including low birth weight, stillbirth, infant illness, and infant death (CDC, 2009b). However, since the NMIHS was last updated in 1991, the data collected through NMIHS may be outdated (CDC, 2009b).

Although there's currently a lack of large scale surveillance datasets and studies that focus on children, fetus, and pregnant women in the Great Lakes Basin, there are a few small-scale research studies that have assessed maternal exposure to harmful substances associated with Great Lakes fish consumption (McGraw et al., 2009; Stewart et al., 1999). For example, McGraw & Waller (2009) examined the relationship between the consumption of Great Lakes fish and the concentration of organochlorines in maternal serum among a group of low income, city dwelling, pregnant African American women in metropolitan Chicago. Other studies have investigated the relationship between fish consumption and adverse birth outcomes, as mentioned earlier (Buck et al., 2003; Karmaus et al., 2004; Weisskopf et al., 2005). Lastly, there is concern that breastfeeding women in the Great Lakes area may have chemicals like PCB in breast milk, from consuming fish. A study of lactating women in the New York State Angler cohort found higher levels of PCBs and pesticides in the breast milk of women who ate fish from Lake Ontario as compared with women who did not eat Lake Ontario fish (Kostyniak et al., 1999).

Population Living in the Areas of Concerns

Based on Annex 2 of the 1987 Agreement, the federal governments identified 43 areas of concern (AOCs), including 26 in the United States, 12 in Canada and five in shared waters. These designated areas had suffered serious bacterial or chemical degradation, failed to meet the 1987 Agreement's specific objectives and were likely to have compromised the area's ability to support aquatic life. At the outset, each of the 43 AOCs had at least one and as many as 14 beneficial use impairments (BUIs). Examples of BUIs include loss of fish habitat or contaminants in fish serious enough to prompt consumption warnings. There were a total of 409 BUIs spread across the 43 AOCs. In the past quarter century, only four of the AOCs have been restored to the point that they were delisted. Recently, a fifth area of concern, Presque Isle Bay was recently delisted and two of them improved enough to be considered areas in recovery (U.S. EPA, 2013b). In the United States, 33 of 255 BUIs have been removed. In Canada, 54 of 154 were removed. Currently both governments have stated that they will make a more aggressive effort to delist more AOCs and further remove BUIs. To accelerate progress toward meeting these objectives, adequate resources need to be made available by both federal governments. In addition, accountability and responsibility need to be assigned to specific agencies to help accelerate progress (International Joint Commission, 2013).

As part of the Great Lakes Health Effects Program, Health Canada prepared a comprehensive analysis that examined incidences rate of diseases in the 17 AOCs in Canada using the health statistics compiled by Statistics Canada, including mortality, morbidity, hospitalization, birth weights and congenital

anomalies (Gilbertson et al., 2001). However, there have been no additional follow up studies since the publication of the report. In the United States, since 1992, the Agency for Toxic Substances and Disease Registry through the Great Lakes Human Health Effect Research program through various research initiatives that have examined the potential short and long term health effects associated with consumption of Great Lakes Fish. In 2001, in response to the IJC's request to examine health impact of environmental contaminations in the Great Lakes AOCs, the ATSDR published the Great Lakes Areas of Concern report to help inform policy and research related to the AOCs. While the draft version of the report was initially released in 2004 for peer review and comments, after a series of revisions, the final report was released in 2008. Similar to the Health Canada study, the ATSDR's Great Lakes Areas of Concern report was a standalone study and no additional data has been collected since the report was released in 2008 (ATSDR, 2008).

A few research studies have attempted to integrate health outcome data with water and air pollution data in the Great Lakes AOCs. About a decade ago, a group of researchers from the McMaster Institute of Environment and Health published a study that used a geographical information system to present a number of health outcomes that are plausibly related to water pollution in the Great Lakes AOCs (Elliott et al, 2001). This was primarily used as a hypothesis-generating exercise and demonstrates a number of environmental-health relationships in this area for which health data are available for further investigation. In 2005, as part of a Windsor AOC case study, another group of researchers linked respiratory hospitalization data with ambient air pollution data (e.g. nitrogen dioxide, sulfur dioxide, carbon monoxide, ozone, particulate matter) to help inform policy makers about risk estimates of respiratory hospitalization based on the level of air pollution in Windsor AOC (Luginaah et al., 2005). Associations were found between all pollutants and daily hospital admission of respiratory diseases especially among females.

Other Vulnerable Populations: Low-Income, Racial Minority, Fish Anglers, Frequent Fish Consumers,

Aside from Aboriginal/Tribal communities, children and pregnant women and the communities living in the Areas of Concerns, there also other vulnerable populations, such as the low-income population, racial minorities and fish anglers that may be particularly susceptible to the exposure of environmental contaminants in the Great Lakes basin.

Similar to the other vulnerable populations, most of the existing exposure or health outcomes datasets related to-income population racial minorities and fish anglers are mostly found in standalone studies.

To date, there have numerous studies that have examined the exposure of environmental contaminants and its associated health outcomes among the fish anglers and frequent fish consumers population in the Great Lakes Basin (Courval et al., 1999; Beehler et al., 2002; Falk et al., 1999; Turyk et al., 2006; Tomasallo et al., 2010; Courval et al., 1996). For example, in 1999, a group of researchers from Michigan State University gathered sport-caught fish consumption and conception delay data from 1443 licensed anglers in the 10 counties in Michigan to assess the association between sport-caught fish consumption and the risk of conception delays (Courval et al., 1999). Similarly, there was a cohort study conducted by the University of Illinois to assess the relationship between level of PCB, dioxin and furan and DDE in the blood samples and Great Lakes sport-caught fish consumers (Turyk et al., 2006).

Aside from McGraw & Waller (2009)'s study, which examined the relationship between the consumption of Great Lakes fish and the concentration of organochlorines in maternal serum among a group of low income, city dwelling, pregnant African American women in metropolitan Chicago, there's currently a lack of exposure studies that have focused on the racial minority and low-income population in the Great Lakes Basin.

6 Objective 3: Challenges, Barriers and Opportunities

This section examines the challenges and barriers to environmental health surveillance integration in the Great Lakes Basin and identifies potential opportunities for future initiatives.

6.1 Emerging Themes

Nine themes emerged based on the findings from the literature review and expert consultations. Participants in the expert consultations and sources from the literature review identified nine themes as the key underlying factors that affect environmental health surveillance integration in the Great Lakes Basin.

The nine themes are:

- (1) Data Availability
- (2) Data Accessibility
- (3) Data Harmonization
- (4) Stakeholder Collaboration
- (5) Policy and Strategic Alignment
- (6) Resource Adequacy
- (7) Environmental-Human Health Indicators and
- (8) Data Exchange Network
- (9) Capability for Long-term Trend Analysis

Data Availability

Data availability is the extent to which environmental stressors, environmental hazards, human exposure and human health outcomes data are collected in the Great Lakes Basin, and is obviously a basic requirement for environmental-human health surveillance integration and studies of associations. Data availability includes both the generalizability and specificity of existing datasets. Ideally, the available datasets should be generalizable to represent the entire Great Lakes Basin, but should also allow analysis of sub-regions or specific parts of the Great Lakes Basin.

Data Accessibility

Data accessibility describes the extent to which environmental-human health surveillance datasets can be accessed and used by key stakeholders (such as researchers and public health departments) in the Great Lakes Basin. Restricted datasets are a barrier to integration of environmental and human health information. The inability to access environmental-human health data as a result of technical, political and legal reasons has been recognized by experts in the literature as one of the key barriers to environmental-human health surveillance integration (WHO Regional Office for Europe, 2005; Liu et al., 2012; Abelsohn et al., 2009; Love et al. 2008).

Data Harmonization

Data harmonization describes the extent to which existing environmental-human health datasets share a common data structure, temporal and spatial scope. Data harmonization enables direct comparison and data integration. The lack of standardized data structure and varying temporal and spatial scope of existing surveillance programs has been noted as one of the key challenges to environmental-human health surveillance integration (Liu et al., 2012; Abelson et al., 2009; Kyle et al., 2006).

Stakeholder Collaboration

Stakeholder collaboration describes the extent to which stakeholders work together to develop a common understanding of the environmental-human health surveillance needs in the Great Lakes Basin (i.e. what data needs to be collected and for what purpose). Stakeholder collaboration has been noted by experts as one key component of environmental health surveillance data integration (CDC, 2011g; Statistics Canada, 2008; Kyle et al., 2006; McGeehin et al., 2004; Mather et al, 2004). Specifically, experts highlighted the importance of having a participatory approach and the value of seeking input and buy-in from key stakeholders and partners early in the planning and development process (CDC, 2011g; McGeehin et al., 2004). On-going collaboration among various levels of the government and jurisdictions and environmental and health agencies is essential to the success of environmental-human health surveillance integration (Abelson et al., 2009). A low level of interdisciplinary collaboration has been cited as one of key challenges to environmental-human health data integration (Liu et al., 2012).

Policy and Strategic Alignment

Policy and strategic alignment describes the extent to which decisions and adopted course of actions related to surveillance activities in the Great Lakes Basin are aligned to achieve a common objective. In the absence of a common understanding of the environmental-human health surveillance needs, existing surveillance programs are developed independently from each other, resulting in datasets that are narrow in scope and that are not designed for the purpose of environmental-human health surveillance (Liu et al., 2012). Based on lessons learned from existing environmental-human health integration efforts, one of the first steps to environmental-human health surveillance integration is for stakeholders to clearly identify and agree upon on a set of core surveillance needs and priorities (McGeehin et al., 2004).

Resource Adequacy

Resource adequacy describes the extent to which funding, personnel and time are available and allocated for the purpose of environmental health surveillance data integration in the Great Lakes Basin. Resource adequacy plays an important role in shaping the design and scope of surveillance programs. Given the vast landscape of the Great Lakes Basin, experts indicated that the effort required to conduct an extensive environmental hazard surveillance program can be very costly, time consuming and resource intensive. As such, with only a finite amount of resources available, environmental hazard data are typically collected at selected monitoring locations and may not be collected on a regular basis. Similarly, given the high cost associated with biomonitoring programs, biomonitoring data cannot be collected extensively (Abelsohn et al., 2009). Based on the experiences of existing environmental-human health tracking initiatives, the collection and integration of environmental-human health datasets can be quite costly and time consuming and substantial resources would be required (Kyle et al., 2006; CDC, 2011g). Public health infrastructure and a trained workforce have been noted as two of the key resource challenges of integrating environmental and human health surveillance data (McGeehin et al., 2004; Litt et al., 2004).

Environmental-Human Health Indicators

Environmental-human health indicators are agreed upon measures used to describe the interactions between human health and the Great Lakes ecosystem. Environmental-human health indicator development is a key component of environment-human health surveillance integration because indicators reflect the environmental-human health surveillance needs in the Great Lakes Basin and determine the type of parameters that need to be measured and collected as part of the existing surveillance program in the Great Lakes Basin (Kyle et al., 2006; Abelsohn et al., 2009; CDC, 2011g; Corvalan et al., 1999; Kjellström & Corvalán, 1995). A wide range of environmental-human health indicators are used in environmental public health tracking programs in the United States and Europe (WHO, 2004; CDC, 2012j). Examples of existing environmental-human health indicators include exposure to ozone in outdoor air, infant mortality from respiratory diseases, prevalence of birth defects, hospitalization for asthma, and level of environmental chemicals in blood and urine (WHO, 2004; CDC 2012j).

Data Exchange Network

A data exchange network describes the system of tools, centralized platforms, and data sharing agreements and reporting standards that would facilitate the sharing of various sets of data among stakeholders in the Great Lakes Basin. Most of the existing datasets are stored in individual databases and are managed by various information technology infrastructures which may not be compatible with each other (Liu et al., 2012; CDC, 2011f). To facilitate integration of environmental and health data, data sharing mechanisms, including common standards and a common information technology platform, need to be in place to allow stakeholders to upload and retrieve datasets in a centralized location (CDC, 2011g; Mather et al, 2004). The lack of data sharing mechanisms among key stakeholders has been noted as one of challenges to integrating environmental and health datasets (Liu et al., 2012).

Capability for Long-term Trend Analysis

Continuous surveillance over time provides significant added value by providing for concurrent analysis of long term trends rather than relying on episodic data abstracted for a single study or short series of studies. In cases where multiple data sets can be merged around questions at the overlap of human health and the environment, this value further increases. Mechanisms that support trend analysis and margining of long term databases require support in addition to the surveillance networks themselves.

6.2 Environmental-Human Health Integration Framework

Based on the themes extracted from the expert consultations and literature review in Section 6.1, a framework was developed to illustrate the interactions and underlying factors that affect environmental health surveillance integration in the Great Lakes Basin. As noted by experts, data availability, data accessibility and data harmonization are the building blocks of environmental-health surveillance integration. As such, the lack of available, scalable, accessible, and/or harmonized environmental and health datasets can be potential barriers to environmental health surveillance data integration.

Other factors, such as stakeholder collaboration, policy and strategic alignment, resource adequacy, environmental-human health indicators, data exchange network, affect the availability, accessibility and harmonization of existing surveillance datasets. Collaboration among stakeholders provides the opportunity for stakeholders to develop a common understanding of the environmental-human health surveillance needs in the Great Lakes Basin and to align policies and actions as appropriate. With a

common understanding, stakeholders can develop environmental-human health indicators to address the specific environmental health surveillance needs in the Great Lakes Basin. Once policies and strategies are aligned, stakeholders can allocate the appropriate level of resources to support the monitoring of the Great Lakes Basin environmental-human health indicators and to facilitate the integration of these indicators through the development of a data exchange network. The lack of stakeholder collaboration, policy and strategic alignment, resource adequacy, the development of environmental-human health indicators and the development of Great Lakes Basin Environmental-Human Health Data Exchange Network can act as potential barriers to integration.

7 Objective 4: Gap Analysis and Challenges

Recognizing the underlying factors that affect environmental-human health surveillance data integration in the Great Lakes Basin, an analysis was conducted to systematically identify the data gaps and limitations in the existing environmental health surveillance datasets in Canada and the United States.

7.1 Data Gaps and Limitations

Based on the findings from the literature review and expert consultations, there are numerous gaps in the existing environmental and human health datasets that can act as potential barriers to integration in the Great Lakes Basin. This section will discuss these limitations and challenge in terms of the availability, scalability, accessibility and compatibility of existing environmental human health surveillance datasets.

Data Availability

- **Most of the existing environment-human health surveillance datasets in Canada and the United States are typically collected at the national, provincial or state level. As such, the existing datasets frequently cannot easily be generalized to represent the entire Great Lakes Basin or be applied to analyze sub-regions or specific parts of the Great Lakes Basin.**

To date, most of the Great Lakes specific datasets are collected through environmental hazards monitoring programs that track environmental hazards, such as air quality, water quality, and fish contamination, in the Great Lake Basin. While many of the existing health outcomes data are linked to

small geographic units, such as the census tract, counties, residential codes and electoral areas, and can be extracted to represent the specific local conditions of the Great Lakes population, most of the human exposure data are collected from a small number of sampling locations across the country and cannot be used to represent the specific needs of the Great Lakes population. As such, most of the existing human exposure datasets relevant to the Great Lakes population are captured in research studies, such as the National Human Exposure Assessment Survey (NHEXAS) Phase 1 field study and the Contaminants in Human Tissues Survey.

- **The characteristics and scope of the existing environmental stressors and hazards datasets in Canada and the United States are limited by the environmental regulation, compliance and enforcement of the specific jurisdictions and are not designed for the purpose of environmental-human health surveillance in the Great Lakes Basin.**

Today, facilities in Canada and United States are regulated by two different legislations. While the Canadian Environmental Protection Act, 1999 prescribes the reporting requirements for NPRI, reporting requirement for TRI is largely dictated by the Emergency Planning and Community Right-to-Know Act and Pollution Prevention Act (PPA) in the United States (Environment Canada, 2012a; U.S. EPA, 2013c). As such, not only will the type of data collected, the frequency of data collection, the location of data collection, and the collection methods be different for TRI and NPRI, the data collected through these two inventories may not be relevant to the environmental-human health surveillance needs in the Great Lakes Basin. For example, both TRI and NPRI require facilities that exceed the maximum contaminant level (e.g. facilities that manufacture, use or process more than 5 kg or 10 lbs.) to report on an annual basis (Environment Canada, 2011d; U.S. EPA, 2012j). Currently, no data is collected on facilities that discharge chemicals below the maximum contaminant threshold. In the context of the Great Lakes Basin, a facility could discharge chemicals below the maximum contaminant threshold, but impact an Aboriginal community situated downstream that relies on the local water as a food source.

The characteristics and scope of the existing environmental stressors and hazards datasets in Canada and the United States are shaped by the two countries' environmental regulations and standards (Mather et al, 2004). Since the existing environmental enforcements and regulatory programs are not designed specifically to address environmental health concerns in the Great Lakes Basin, Great Lakes Basin specific environmental stressors and hazards may not be available. For example, agricultural run-

offs are an important contributor to harmful algal bloom in the Great Lakes Basin (Environment Canada, 2012b). In the absence of mandatory environmental reporting requirements from agricultural operations in Canada and the United States, environmental stressors data related to agricultural operations, such as run-offs, impacts of heavy rainfall events, nutrient management, and pesticide use, are not collected in an on-going and systematic manner.

- **To date, human exposure data that specifically targets the population in the Great Lakes Basin are not readily available in Canada and the United States.**

The current study finds that human exposure data continues to be relatively lacking compared to the other types of datasets (Figure 2) This is consistent with earlier findings (Mather et al, 2004). While Canada and the United States have developed biomonitoring programs at the national level, most of the data cannot be scaled to be representative of the Great Lakes population. To date, aside from a few standalone research studies, the National Human Exposure Assessment Survey (NHEXAS) Phase 1 field study and the Contaminants in Human Tissues Survey are the two key human exposure datasets that are representative of the population or subpopulation in the Great Lakes Basin. While exposure estimates studies and projects, such as CAREX and Total Diet Study, have been used to estimate population' exposure to environment contaminants at the national level, modeling and exposure estimate techniques have not been used extensively to measure human exposure in the Great Lakes Basin.

- **Most of the existing environment-human health surveillance datasets in Canada and the United States have not put a strong focus on the vulnerable/at risk population in the Great Lake Basin (children, fetus, pregnant women, people living in the AOC, Aboriginal/Tribal communities).**

While Canada and the United States collect data on maternal, fetal and infant health through nation-wide or provincial-wide surveillance databases and studies, such as Ontario Maternal Serum Screening Program (Public Health Agency of Canada, 2005b), PRAM, and MIREC, most of these studies and databases are designed at the national level and are not representative of the children, fetus and pregnant women in the Great Lakes Basin. Today, most of the existing environment-human health surveillance datasets on the children, fetus, and pregnant women in the Great Lakes Basin are captured

in standalone research studies (McGraw et al., 2009; Stewart et al., 1999; Witkowski et al., 1992; Buck et al., 2003; Swain, 1991; Karmaus et al., 2004; Karmaus et al., 2009; Weisskopf et al., 2005).

Similarly, there's not a lot of environmental-human health surveillance data collected from the Aboriginal/Tribal population living in the Great Lakes Basin. To date, the Statistics Canada's APS and the Health Canada's HERS are the two key national surveillance systems that collect environment-human health data from the Aboriginal population in Canada. In the United States, most of the environmental-human health data relevant to the Tribal populations are collected through research studies funded by the CDC's Tribal Environmental Health Research Program. To date, the Contaminants in Human Tissues Survey is the only large scale datasets that specifically focus on the Aboriginal communities' exposure to environmental hazards in the Great Lakes region (Davies, 2001).

Finally with respect to the population living in the AOCs, although there were several studies that had examined the impact of environment hazards in the Great Lakes Basin on the population living in the AOCs, no follow up or additional data were collected since the publication of these studies.

Data Accessibility

- **The existing environmental-human human surveillance datasets in Great Lakes Basin cannot be accessed through a common portal.**

Today, health and environmental datasets relevant to the Great Lakes Basin are managed and stored separately by various state, provincial, national environmental and health agencies in Canada and the United States. In order to access these datasets for the purpose of integration, researchers would need to contact the different organizations and also to comply with a wide range of data access policies. While some data are publically available and can be accessed directly online (e.g. National Air Pollution Surveillance (NAPS)), for other datasets (e.g. ICES Discharge Abstract Database), researchers would need to go through an application process and would need to travel to a secured onsite location to access the data. Even within a jurisdiction, while similar datasets may be collected by different state organizations these datasets are not stored at a centralized location, for example Illinois State Water Survey and Illinois Environmental Protection Agency both collect well data. Additionally, the responsible agency that monitors and collects environmental and human health data may vary across the different Great Lakes states and provinces. For example, in Ohio, the Department of Natural Resources is responsible for monitoring water quality data, while in Illinois, the water quality data is collected by both the Illinois Environmental Protection Agency and Illinois State Water Survey. Researchers and other potential data

users would need to have an in-depth understanding of the state or provincial governance structure in order to know where to find and access the data they need to conduct environment-human health research in the Great Lakes Basin. This inconvenience associated with the different data collection and access policies is a significant barrier to effective integration and use of the data that is collected.

- **Due to the concerns related to privacy and confidentiality, there is limited access to record level health datasets in Canada and the United States.**

Today, while most of the environmental data in the United States and Canada can be made available to the public upon request, access to health surveillance data is somewhat restrictive (Love et al, 2004). On both sides of the border, health data available for public uses are often aggregated (McGeehin et al., 2004). To respect the privacy and confidentiality of the individuals, de-identified, record level health outcome and exposure surveillance datasets in Canada and United States are not publically available. Scientists and researchers can only have access to these de-identified, record levels at secured on-site locations, such as Statistic Canada's Research Data Centres, and CDC's National Center for Health Statistics' Research Data Centres or ICES offices upon request and after an application and approval process. To access identifiable, record-level health outcomes datasets, in most cases, researchers would need to obtain authorization and consent from the individual participants (United States Department of Health and Human Services, 2007; Canadian Institutes of Health Research, 2006).

While it may be difficult to access record level health data through the existing administrative databases, it is important to note that de-identified, record level data are often captured in various research studies. A recent cohort study examining concentrations of PCB and DDE in pregnant African American women is an example of a research study using de-identified, record level health data (McGraw & Waller, 2009). It is important to note that publicly available aggregated datasets linked to small geographical units, such as census tracts, counties, residential codes and electoral areas, can be extracted and used to identify specific exposure concerns in local areas of the Great Lakes Basin.

Data Harmonization

- **Most of the existing environmental and health datasets in Canada and the United States do not have a common temporal/spatial scope and standardized data structure.**

In the absence of a common reporting standard for Great Lakes environment-human health data, the existing datasets are collected at varying times and for different purposes by various stakeholders at

different levels of government or jurisdictions. The varying data structure and spatial scale across datasets have been noted in the literature as one of the barriers to linking environmental and human health data (Mather et al, 2004).

In recent years, both the environment and public health sector have begun to develop initiatives to harmonize datasets within their own sector. For example, in the United States, water quality data in the United States are harmonized through the EPA's Environmental Information Exchange Network (U.S. EPA, 2011). For research studies, sophisticated modeling techniques have been used to harmonize small datasets for specific research studies (Mather et al., 2004; Nevers and Whitman, 2005). Aside from the Washington Fish Tissue Data project and the CDC's National Environmental Public Health Tracking System, in general, environmental and human health data are generally not temporally and spatially compatible. To date, there has not been a basin-wide initiative to harmonize key environmental and human health datasets across the Great Lakes Basin.

7.2 Other Considerations: Drivers

Drivers, such as stakeholder collaboration, policy alignment, and data exchange tools, and availability of resources, often play an important role in shaping the characteristics of the environmental health surveillance dataset. Understanding the underlying drivers that affect the existing datasets can lead to a better understanding of the root causes of the problem and identify potential leverage points for future interventions.

Stakeholder Collaboration

- **Currently, there are few knowledge exchange initiatives and cooperatives efforts among the health and environmental stakeholder groups in the Great Lakes Basin.**

In general, there has been a growing interest in data integration and knowledge exchange among health and environmental organizations in Canada and United States. Both the environment and public health sector have begun to develop initiatives and tools to facilitate data exchange within their own sector. Specifically, over the past decades, a few initiatives have been developed to coordinate surveillance activities among the diversity of stakeholders in the Great Lakes area. In the late 1980s the Binational Executive Committee (BEC), comprised of key environmental stakeholders from Canada and United States, was formed to carry out activities and programs to fulfill the requirements set out by the Great Lakes Water Quality Agreement (Richardson et al., 2012). The Great Lakes Interagency Task Force and

Regional Collaboration were established in 2004 by an executive order to improve federal coordination and harmonize goals. This effort was implemented to a great extent by the Great Lakes Restoration Initiative. More recently, the Cooperative Science and Monitoring Initiative was formalized to institutionalize and coordinate environmental related monitoring and research field activities in the Great Lakes region (Richardson et al., 2012). However, the coordinated initiatives in the Great Lakes Basin to date have a strong focus on environmental surveillance and monitoring. While the Chemical Management Plan in Canada and the CDC National Environmental Public Health Tracking System have forged partnerships between environmental and health stakeholders at the national level, there have been limited knowledge exchange initiatives and cooperatives efforts, especially among health stakeholders in the Great Lakes area.

Policy and Strategic Alignment

- **In the absence of a basin-wide environmental-human health surveillance strategy, the existing resources, environmental health indicators, and data exchange system in Ontario and the Great Lakes States are not designed to specifically meet the environmental-human health surveillance needs and priorities of the Great Lakes Basin.**

In the absence of a strong collaborative effort among the health and the environmental sectors in Canada and the United States, surveillance initiatives in the Great Lakes area have largely been developed independently and without inter-agency collaboration. As such, the availability and the format of existing datasets in Canada and the United States varies depending on the needs and resource capacity of the jurisdictions. To date, most of the strategies and policies related to the Great Lakes region, such as the Great Lakes Binational Toxic Strategy and the Great Lakes Regional Collaboration Strategy have focused on ecosystem health and not human health. In addition to aligning environmental and health surveillance priorities in the Great Lakes Basin, a basin-wide environmental health surveillance program would require the integration of environmental and public health surveillance data from Ontario with data from eight Great Lakes States of Wisconsin, Minnesota, Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York.

Resources Adequacy

- **To date, the majority of funding and resources for existing surveillance programs in the Great Lakes Basin comes from environmental organizations. Perhaps as a result, the existing surveillance activities in the Great Lakes Basin have placed a strong emphasis on the health of the Great Lakes ecosystem and have placed relatively little emphasis on human health.**

Today, most surveillance initiatives are funded by environmentally focussed government departments or agencies, non-governmental organizations or community based advocacy groups. Most of the large scale Great Lakes monitoring initiatives, such as the Great Lakes Information Network, and Great Lakes Observing Systems, are funded and supported by environmental organizations such as the Great Lakes Commission and Coastal Services Center of the National Oceanic and Atmospheric Administration.

In Canada, the Ontario Ministry of Natural Resources, OMOE, Environment Canada and Department of Fisheries and Oceans fund a large portion of the surveillance activities in the Great Lakes region. Although Health Canada and the Ontario Ministry of Health and Long Term Care have been involved in supporting a few Great Lakes surveillance and monitoring activities, such as the Great Lakes Human Effects Programs, Great Lakes Border Health Initiatives, Contaminants in Human Tissues Survey, in comparison to the environment sector, the health sectors play a much smaller role in supporting surveillance activities in the Great Lakes Region. Similarly, the U.S. EPA, Coastal Services Center of the National Oceanic and Atmospheric Administration and state-level environmental agencies are the main sources of funding for surveillance activities in the Great Lakes region. In the United States, the CDC's ATSDR also plays an active role in supporting surveillance initiatives in the Great Lakes Basin through their Great Lakes Human Effects Program. However, the health sector in the United States does not play a significant role in supporting surveillance and monitoring activities in the Great Lakes area.

Environmental-Human Health Indicators

- **To date, there are few Great Lakes Basin Environmental-Human Health Indicators to track and monitor the health of the human population in the Great Lakes Basin.**

Of the 77 indicators established under the United States-Canadian State of Lakes Ecosystem Conference (SOLEC) to monitor the health of Great Lakes basin, only a handful of indicators are related to human health. To date, there are five human impact SOLEC indicators: Beach Advisories, Cladophora, Drinking Water Quality, Fish Consumption Restrictions, and Harmful Algal Bloom (SOLEC State of the Great Lakes,

2009; SOLEC Great Lakes Indicator Review, 2011; SOLEC Draft Indicator Reports, 2012). Recently, in conjunction with this environmental health surveillance integration project, the IJC HPAB has also begun to examine the development of environmental-human health indicators for the Great Lakes region.

Data Exchange Network

- **While there are existing data exchange initiatives developed in the United States, data exchange networks, similar data exchange initiatives have not yet been established in the Province of Ontario or in Canada.**

Over the past decade, the US EPA and the CDC have placed significant resources into developing tools and systems to facilitate the sharing of environmental and health data across the United States. Recently, the US EPA established the Environmental Information Exchange Network to provide a centralized technology platform that facilitates the sharing and use of environmental data (U.S. EPA, 2011). The Environmental Information Exchange Network enables stakeholders to connect and exchange data with other partners securely online (U.S. EPA, 2011). To address potential compatibility concerns, the network uses XML to standardize the data structure (U.S. EPA, 2011). Furthermore, to resolve any potential data accessibility concerns, as part of the process, partners work together to develop data sharing agreements at the initial phase of the project (U.S. EPA, 2011). Through this network, initiatives such as the GLENDa Query System, Great Lakes Node project and the Geo-Exchange with Region 5 and Wisconsin Department of Natural Resources have been established to facilitate environmental data exchange within the Great Lakes Basin.

In 2002, in response to the recommendations from the Pew Environmental Health Commission report 'America's Environmental Health Gap: Why the Country Needs a Nationwide Health Tracking System', the CDC initiated the development of the National Environmental Public Health Tracking program. The purpose of this program is to facilitate the integration and dissemination of environmental hazard human exposure and health effects surveillance across the United States (CDC, 2011g). Currently, the program provides grants to 23 states and 1 city as a way to facilitate the development and implementation of state-wide and local environmental public health tracking network (CDC, 2011h). In addition, as part of the Peer Fellowship program, the National Environmental Public Health Tracking program also provides 13 states with the necessary tools and training to build their own local tracking networks (CDC, 2011h). CDC's National Environmental Public Health Tracking System has been used in a wide range of applications, including public education, policy development, targeted prevention, and

identification of at risk communities. For example, in California, the tracking system has been used to identify the increase in preterm rates in California County, to inform policy about heat wave preparedness and to develop a traffic tool for city planning (CDC, 2011i). While all eight Great Lakes states are part of the National Environmental Public Health Tracking Network, it is important to note that this initiative is designed at the state and national level and is not tailored specifically to environmental-human health surveillance needs in the Great Lakes Basin.

Based on the literature review and expert consultations, we conclude that comparable data exchange initiatives have not yet been established in the Province of Ontario or in Canada.

7.3 Case Studies

Based on discussion with a small group of Canadian and United States Environmental and Human Health experts in Toronto on March 21, 2013 as part of an expert consultation, case studies were suggested as a way to further refine and focus database integration activities. Some cases studies being considered for further development include:

- St Clair River Area of concern for a study of merged Michigan and Canadian asthma data.
- Developing a model for cross-boundary collaboration by surveying New York state and Ontario epidemiologists to determine:
 - i. What specific types of research could be done with better data integration /data exchange facilities?
 - ii. What do researchers need in order to better study associations between environmental contaminants and human health in the Great Lakes basin?
 - iii. What types of data exchange would work-in terms of ease of use, and utility for research?
 - iv. What barriers currently exist for cross-border collaboration to do research on environmental –human health associations in the Great Lakes region?

7.4 Summary of Findings

The following summary of the findings from the gap analysis:

Environmental-Human Health Surveillance Integration in the Great Lakes Basin

- While environmental and health data relevant to the Great Lakes Basin have not been well integrated more broadly, there are several examples of research studies that have been conducted in the region that integrated these data for specific health outcomes. Among the few studies that have attempted to integrate environment and health data in the Great Lakes Basin, most of the existing studies focused primarily on linking reproductive outcomes with the consumption of contaminated Great Lakes fish (e.g. low birth weight, decreased head circumference, and earlier gestational age). Follow-up studies of these infants report associations with neurobehavioural deficits including poorer motor reflex and neuromuscular functioning and depressed responsiveness. Other health outcomes that have been found to be associated with contaminants in the Great Lakes include diabetes, memory and learning impairments, and uterine fibroids.

There have been a few studies with a specific focus on the Great Lakes AOC's that have integrated health outcome data with water and air pollution data. A study in Windsor linked respiratory hospitalization data with several air pollutants and found several statistically significant associations (Luginaah et al., 2005). A study prior to this presented Health Canada health outcome data using a GIS of the Great Lakes AOC to help generate hypotheses about associations by applying a spatial lens (Elliott et al, 2001).

Data Availability

- Most of the existing environment-human health surveillance datasets in Canada and the United States are typically collected at the national, provincial or state level. As such, the existing datasets frequently cannot easily be generalized to represent the entire Great Lakes Basin or can easily be applied to analyze sub-regions or specific parts of the Great Lakes Basin.
- The characteristics and scope of the existing environmental stressors and hazards datasets in Canada and the United States are limited by the environmental regulation, compliance and

enforcement of the specific jurisdictions and are not designed for the purpose of environmental-human health surveillance in the Great Lakes Basin.

- To date, human exposure data that specifically targets the population in the Great Lakes Basin are not readily available in Canada and the United States.
- Most of the existing environment-human health surveillance datasets in Canada and the United States are national in scope and as such do not provide data on the vulnerable/at risk population in the Great Lake Basin (children, fetus, pregnant women, people living in the AOC, Aboriginal/Tribal communities).

Data Accessibility

- The existing environmental-human human surveillance datasets in Great Lakes Basin cannot be accessed from a common portal.
- Due to the concerns related privacy and confidentiality, there is limited access to record level health datasets in Canada and the United States.

Data Harmonization

- Most of the existing environmental and health datasets in Canada and the United States do not have a common temporal/spatial scope and standardized data structure.

Stakeholder Collaboration

- Currently, there is a lack of knowledge exchange initiatives and cooperatives efforts among the health and environmental stakeholder groups in the Great Lakes Basin.

Policy and Strategic Alignment

- In the absence of a basin-wide environmental-human health surveillance strategy, the existing resources, environmental health indicators, and data exchange system in Ontario and the Great Lakes States are not appropriately designed to meet the environmental-human health surveillance needs and priorities of the Great Lakes Basin.

Resource Adequacy

- To date, the majority of funding and resources for existing surveillance programs in the Great Lakes Basin comes from environmental organizations. As such, the existing surveillance activities in the Great Lakes Basin have placed a strong emphasis on the health of the Great Lakes ecosystem and have placed very little emphasis on human health.

Environmental-Human Health Indicators

- To date, there is a limited number of Great Lakes Basin Environmental-Human Health Indicators to track and monitor the health of the human population in the Great Lakes Basin.

Data Exchange Network

- While there are existing data exchange initiatives developed in the United States, data exchange networks, similar data exchange initiatives have not yet been established in the Province of Ontario or in Canada.

8 Objective 5: Conclusion and Recommendations

An expert consultation was held March 21-22, 2013 in Toronto, ON, in which a small group of Canadian and United States experts provided feedback for this report and advice for Phase 2 activities for this project. The outcomes from this consultation included:

- Discussion of existing national/provincial/state activities in the United States and Canada that merge health and environmental databases as a prelude to developing a framework to Great Lakes coordination activities;
- Discussion of challenges facing government, institutions, public health researchers and the general public in accessing and integrating environmental and health data to understand environment-human health associations
- A better understanding of health surveillance needed to support Great Lakes human health indicators.

Currently neither health nor environmental exposure data are collected in a way that allows examination of associations in the Great Lakes ecosystem. The existing national health surveys, although designed to be nationally representative, cannot be used to ascertain environmental health risks for the Great Lakes Basin and compare them to the rest of the two countries.

The following set of recommendations addresses these and other concerns about the integration of environmental-human health surveillance data in the Great Lakes Basin:

Recommendation #1: That governments actively engage with public health practitioners, academic researchers, and community groups that represent vulnerable communities in the Great Lakes Basin to identify priority areas for data integration. This report has illustrated the vast data sources that could potentially be integrated, however, it will be important for the data users to identify knowledge gaps and priorities for surveillance that the integration process could address.

Recommendation#2: That governments explore the potential of building onto databases already in place (e.g., Great Lakes Observing System) and/or projects that have already developed exposure estimate techniques and models for similar purposes (e.g., CAREX Canada). These existing projects have the potential to be extended by sampling in the Great Lakes Basin to develop a dataset that is more representative of the Great Lakes Basin population.

Recommendation #3: That the two parties establish a cooperative data management system for human health and environmental exposure for the Great Lakes Basin, providing access to data that is accessible to researchers and the general public.

This could be achieved by funding a reference to the IJC, or enhancing existing capacities within governments, such as the IJC's Great Lakes Regional Office or the Great Lakes Observing System, to create a binational data center. Such a center would coordinate and collect health and exposure surveillance information relevant to the Great Lakes Basin in such a way as to permit ongoing monitoring, academic access for particular studies, and public access to the data where appropriate.

Recommendation #4: That governments improve the quality and usability of data by making funding proportional to the quality, accessibility and harmonizability of data collected in the Great Lakes. This should be done in conjunction with a basin-wide initiative to harmonize existing datasets and develop agreements on their joint transboundary use.

Recommendation #5: That the NHANES (National Health and Nutrition Examination Survey) and CHMS (Canadian Health Measures Survey) include an oversampling for the Great Lakes region that will allow comparisons to the rest of the two countries. This is necessary because neither survey is constructed to provide information on which health outcomes occur more or less often in the Great Lakes basin.

Recommendation #6: That the parties expand the suite of human health indicators that provide meaningful information on the state of human health related to the Great Lakes environment. Ideally these should move from the current exposure-based indicators into health outcome indicators. The indicators would then guide decisions about priority areas for better data collection and monitoring of human exposures and associated health impacts.

Recommendation #7: Biomonitoring resources should be focused on two vulnerable sub populations: Young children and pregnant women. Health assessments need to accompany biomonitoring information to make it useful for understanding exposure-health associations.

Recommendation #8: First Nations and Tribal populations have distinct needs for environmental health (for example, vulnerability to water quality problems) and should be considered high priority for environmental and health surveillance.

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Appendix A – Great Lakes Environmental-Human Health Surveillance Inventory

A.1 Environmental Stressors

Canada

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Agricultural Water Survey	Canada	Biennial	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&DDS=5145&lang=en&db=imdb&adm=8&dis=2#a2
Crop Protection Survey	Canadian Provinces	One Time	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&DDS=5100&lang=en&db=imdb&adm=8&dis=2#a2
Farm Environmental Management Survey (FEMS)	Canada	Every 5 years	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&DDS=5044&lang=en&db=imdb&adm=8&dis=2
Farm Inputs Management Survey	Canadian Provinces	One Time	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&DDS=3461&lang=en&db=imdb&adm=8&dis=2#b3
Greenhouse Gas Facility Data	Ontario	Annual	Ontario Ministry of Environment	http://www.ene.gov.on.ca/environment/en/resources/collection/data_downloads/index.htm
Hazardous Waste Information Network: Hazardous Waste data	Ontario	Annual	Ontario Ministry of Environment	http://www.ene.gov.on.ca/environment/en/resources/collection/data_downloads/index.htm
Industrial Water Survey (IWS)	Canada	Biennial	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&DDS=5120&lang=en&db=imdb&adm=8&dis=2
Pesticide Use Survey	Ontario	Every 5 years	Ontario Ministry of Agriculture	http://www.omafra.gov.on.ca/english/crops/facts/pesticide-use.htm

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Livestock Farm Practices Survey	Canadian Provinces	One Time	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5107&lang=en&db=imdb&adm=8&dis=2
Municipal Water and Wastewater Survey	Canada	Occasional	Environment Canada	http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=ED0E12D7-1#wateruse
Municipal/Industrial Strategy for Abatement (MISA) data	Ontario	Quarterly	Ontario Ministry of Environment	http://www.ontario.ca/environment-and-energy/municipalindustrial-strategy-abatement-misa-data
National Pollutant Release Inventory (NPRI)	Canada	Annual	Environment Canada	http://www.ec.gc.ca/inrp-npri/default.asp?lang=en&n=0EC58C98-
Ontario Provincial Highway Traffic Volume Data	Ontario	Annual	Ontario Ministry of Transportation	http://www.raqsa.mto.gov.on.ca/techpubs/TrafficVolumes.nsf/tvweb
Survey of Industrial Processes	Canada	One Time	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5163&lang=en&db=imdb&adm=8&dis=2
Toxics Reduction dataset	Ontario	Annual	Ontario Ministry of Environment	http://www.ene.gov.on.ca/environment/en/resources/collecton/data_downloads/index.htm

United States

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Air Emissions Inventory and Reporting (ARS)	Wisconsin	Annual	Wisconsin Department of Agriculture, Trade and Consumer Protection	http://dnr.wi.gov/topic/airemissions/
Continuous Emission Monitoring	Pennsylvania	--	Pennsylvania Department of Environmental Protection	http://www.dep.state.pa.us/dep/deputate/airwaste/aq/cemspage/cems.htm
Emissions Inventory System	Ohio	Annual	Ohio Environmental Protection Agency	http://www.epa.state.oh.us/dapc/aqmp/eiu/eis.aspx
Environmental Data Access :Solid Waste	Minnesota	--	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/data/solid-waste.html
Environmental Data Access: Petroleum Storage Tanks	Minnesota	--	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/data/petroleum-storage-tanks.html
Environmental Data Access: Surface Water Monitoring Data	Minnesota	--	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/data/contaminated-sites.html
Environmental Data Access:Household Hazardous Waste Collection Sites	Minnesota	--	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/data/recycling-and-pollution-prevention.html
Environmental Data Access: Household Hazardous Waste Collection Sites	Minnesota	--	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/data/hazardous-waste.html
Great Lakes Creel Survey Program	Great Lakes Basin	Annual	Michigan Department of Natural Resources	http://www.michigan.gov/dnr/0,4570,7-153-10364_52259_10951_11301-97829--,00.html

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Hazardous Air Pollutant (HAP) Emissions Inventories/Air Toxics Monitoring Data	Indiana	--	Indiana Department of Environmental Management	http://www.in.gov/idem/toxic/2336.htm
Indiana Lakeshore Air Toxics Screening	Indiana	--	Indiana Department of Environmental Management	http://www.in.gov/idem/toxic/2342.htm
Michigan Air Emissions Reporting System	Michigan	Annual	Michigan Department of Environmental Quality	http://www.michigan.gov/deq/0,4561,7-135-3310_4148-11409--,00.html
Minnesota Air Toxics Emission Inventory	Minnesota	Occasional	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/air/air-monitoring-and-reporting/air-emissions-modeling-and-monitoring/air-toxics-emission-inventory/minnesota-air-toxics-emission-inventory.html
Minnesota Criteria Air Pollutant Emission Inventory	Minnesota	--	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/air/air-monitoring-and-reporting/air-emissions-modeling-and-monitoring/criteria-air-pollutant-emission-inventory/minnesota-criteria-air-pollutant-emission-inventory.html
National Emissions Inventory (NEI)	United States	Annual	United States Environment Protection Agency (EPA)	http://www.epa.gov/ttnchie1/trends/
Pesticide Database	Wisconsin	--	Wisconsin Department of Agriculture, Trade and Consumer Protection	http://datcp.wi.gov/Plants/Pesticides/Pesticide_Databases/index.aspx
Radiological Environmental Monitoring Program	Minnesota	On-going	Minnesota Department of Health (MDH)	http://www.health.state.mn.us/divs/eh/radiation/monitor/
Stationary Source Emissions Inventory	New York	--	New York State Department of Environmental Conservation	http://www.dec.ny.gov/chemical/68524.html
Toxic Release Inventory (TRI)	United States	Annual	United States Environment Protection Agency (EPA)	http://www.epa.gov/tri/tridata/index.html

A.2 Environmental Hazards

Canada

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Canadian Air and Precipitation Monitoring Network (CAPMON)	Canada	--	Environment Canada	https://www.ec.gc.ca/rs-mn/default.asp?lang=En&n=6C8C66C5-1
Canadian Aquatic Biomonitoring Network (CABIN) Database	Canada	--	Environment Canada	http://www.ec.gc.ca/rcba-cabin/
Drinking Water Surveillance Program	Ontario	Annual	Ontario Ministry of Environment	http://www.ene.gov.on.ca/environment/en/resources/collection/data_downloads/index.htm
Fish and Seafood Survey	Canadian Cities	One Time	Health Canada	http://www.hc-sc.gc.ca/fn-an/surveill/other-autre/fish-poisson/index-eng.php
Freshwater Quality Indicator	Canada	Annual	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5128&lang=en&db=imdb&adm=8&dis=2#b3
Global Environment Monitoring System (GEMS)	International	--	Environment Canada	http://www.gemstat.org/default.aspx
Great Lakes Nearshore Monitoring and Assessment Program: Great Lakes Nearshore Index Station Network	Ontario	Occasional	Ontario Ministry of Environment	http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/std01_079737.pdf

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Great Lakes Nearshore Monitoring and Assessment Program: Great Lakes Reconnaissance Survey	Ontario	Occasional	Ontario Ministry of Environment	http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/std01_079737.pdf
Great Lakes Sediment Database	Great Lakes Basin	Annual	Environment Canada	http://www.ec.gc.ca/inrenwri/default.asp?lang=En&n=9890771E-1
Great Lakes Surveillance Program	Great Lakes Basin	Every 2 Years (Each Lake)	Environment Canada	http://www.ec.gc.ca/scitech/default.asp?lang=en&n=3F61CB56-1
Hedgehog Environmental Reporting System	Canada	--	Health Canada	http://www.hc-sc.gc.ca/ewh-semt/pubs/eval/inventory-repertoire/hers-eng.php
Historical Air Pollution Data	Ontario	Hourly	Ontario Ministry of Environment	http://www.airqualityontario.com/reports/aqisearch.php
Historical Air Quality Index Reading	Ontario	Hourly	Ontario Ministry of Environment	http://www.airqualityontario.com/history/
Households and the Environment Survey (HES)	Canadian Provinces	Biennial	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3881&lang=en&db=imdb&adm=8&dis=2
Integrated Atmospheric Deposition Network (IAPN).	Great Lakes Basin	--	Environment Canada US Environmental Protection Agency (EPA)	https://www.ec.gc.ca/natchem/default.asp?lang=En&n=1590DD07-1 http://www.epa.gov/glnpo/monitoring/air2/

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
NAtChem: Canadian Aerosol Baseline Measurements	Canada	--	Environment Canada	http://www.ec.gc.ca/natchem/default.asp?lang=en&n=0AC1992C-1
NAtChem: Greenhouse Gases	Canada	--	Environment Canada	http://www.ec.gc.ca/natchem/default.asp?lang=en&n=7A3F995E-1
NAtChem: National Atmospheric Chemistry/Air Toxics Database	Canada	--	Environment Canada	http://www.ec.gc.ca/natchem/default.asp?lang=en&n=F8BB758A-1
NAtChem: National Atmospheric Chemistry/Particulate Matter Database	Canada	--	Environment Canada	http://www.ec.gc.ca/natchem/default.asp?lang=en&n=6063B57F-1
NAtChem: National Atmospheric Chemistry/Precipitation Chemistry Database	Canada	--	Environment Canada	http://www.ec.gc.ca/natchem/default.asp?lang=en&n=35DDC79D-1
NAtChem: National Atmospheric Chemistry/Special Studies Database	Canada	--	Environment Canada	http://www.ec.gc.ca/natchem/default.asp?lang=En&n=228D9581-1
National Air Pollution Surveillance Network (NAPS) - Dataset	Canada	--	Environment Canada	http://www.ec.gc.ca/rnsps-naps/
National Aquatic Biological Specimen Bank and Database	Canada	On-going	Environment Canada	http://www.ec.gc.ca/inre-nwri/default.asp?lang=En&n=D488F7DE-1
National Contaminants Information System	Canada	--	Fisheries and Oceans Canada	http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/ncis-snic/index-eng.htm
National Fish Contaminants Monitoring and Surveillance Program	Canada	On-going	Environment Canada	http://www.ec.gc.ca/scitech/default.asp?lang=en&n=828EB4D2-1

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Ontario Lake Partner (LPP) data	Ontario	Occasional	Ontario Lake Partner (LPP) Program	http://www.ene.gov.on.ca/environment/en/resources/collection/data_downloads/index.htm
Ontario Sport Fish Contaminant Monitoring Program	Ontario	On-going	Ontario Ministry of Environment Ontario Ministry of Natural Resources	http://www.ene.gov.on.ca/environment/en/resources/collection/guide_to_eating_ontario_sport_fish/index.htm
Provincial (Stream) Water Quality Monitoring Network (PWQMN) dataset	Ontario	Occasional	Ontario Ministry of Environment	http://www.ene.gov.on.ca/environment/en/resources/collection/data_downloads/index.htm
Provincial Groundwater Monitoring Network (PGMN) data	Ontario	Annual	Ontario Ministry of Environment	http://www.ene.gov.on.ca/environment/en/resources/collection/data_downloads/index.htm
Smog Advisory Statistics	Ontario	Annual	Ontario Ministry of Environment	http://www.airqualityontario.com/press/smog_advisories.php
Sport Fish Contaminant Monitoring Program Advisories	Ontario	Biennial	Ontario Ministry of Environment	http://www.ene.gov.on.ca/environment/en/resources/collection/data_downloads/index.htm
Survey of Benzene in Soft Drinks and other Beverage Products	Canada	One Time	Health Canada	http://www.hc-sc.gc.ca/fn-an/surveill/other-autre/benzene_survey_enquete-eng.php
Survey of Drinking Water Plants	Canada	Biennial	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5149&lang=en&db=imdb&adm=8&dis=2
Water Survey of Canada: Hydrometric Data	Canada	On-going	Environment Canada	http://www.ec.gc.ca/rhc-wsc/default.asp?lang=En&n=894E91BE-1
Well Data	Ontario	On-going	Ontario Ministry of Environment	http://www.ene.gov.on.ca/environment/en/resources/collection/data_downloads/index.htm

United States

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Acid Deposition Monitoring Data	New York	Multi-Year	New York State Department of Environmental Conservation	http://www.dec.ny.gov/chemical/41318.html
Acid Rain and Mercury Sites and Data	Pennsylvania	On-going	Pennsylvania Department of Environmental Protection	http://www.dep.state.pa.us/dep/deputate/airwaste/air/aq/acidrain/sitemap.htm
Air Monitoring Data	Illinois	--	Illinois Environmental Protection Agency	http://www.epa.state.il.us/air/air-quality-menu.html
Air Quality Monitoring Data	New York	--	New York State Department of Environmental Conservation	http://www.dec.ny.gov/chemical/8406.html
Air Quality System (AQS)	United States	--	United States Environment Protection Agency (EPA)	http://www.epa.gov/ttn/airs/airsaqs/
Air Quality Monitoring Data	Michigan	--	Michigan Department of Environmental Quality	http://www.michigan.gov/deq/0,4561,7-135-3310_4195---,00.html
Air Toxics Monitoring Data	Ohio	--	Ohio Environmental Protection Agency	http://www.epa.ohio.gov/dapc/atu.aspx
AirOhio	Ohio	--	Ohio Department of Natural Resources	http://www.epa.ohio.gov/dapc/airohio/index.aspx
Ambient Lake Monitoring Program	Illinois	Every 5 years (each Lake)	Illinois Environmental Protection Agency	http://www.epa.state.il.us/water/conservation/almp.html
Ambient Network of Community Water Supply Wells (CWS) Newtork	Illinois	--	Illinois Environmental Protection Agency	http://www.epa.state.il.us/water/groundwater/ambient-monitoring.html
Ambient Water Quality Monitoring Network	Illinois	--	Illinois Environmental Protection Agency	http://www.epa.state.il.us/water/surface-water/river-stream-mon.html#sw1

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Beach Monitoring	Minnesota	On-going	Minnesota Department of Health	http://www.health.state.mn.us/divs/eh/beaches/closure.html
Beach Monitoring	Illinois	On-going	Illinois Department of Public Health	http://app.idph.state.il.us/envhealth/ilbeaches/public/
Beach Monitoring	Indiana	On-going	Indiana Department of Environmental Management	http://www.in.gov/idem/4151.htm
Beach Monitoring	Michigan	On-going	Michigan Department of Environmental Quality	http://www.michigan.gov/deq/0,4561,7-135-3313_3686_3730---,00.html
Beach Monitoring	Ohio	On-going	Ohio Department of Health	http://www.odh.ohio.gov/odhprograms/eh/bbeach/beachmon.aspx
BEACON 2.0 - Beach Advisory and Closing On-line Notification	United States	On-going	United States Environment Protection Agency (EPA)	http://watersgeo.epa.gov/beacon2/
Citizen Lake Awareness and Monitoring	Ohio	--	Ohio Lake Management Society (OLMS)	http://www.olms.org/clam.php
Citizen Lake Monitoring Network	Wisconsin	Occasional	Wisconsin Department of Natural Resources	http://dnr.wi.gov/lakes/CLMN/
Citizen Stream/Lake Monitoring Program	Minnesota	On-going	Minnesota Pollution Control Agency	http://cf.pca.state.mn.us/water/cmp/search.cfm
Citizens Statewide Lake Assessment Program Data	New York	Occasional	New York State Department of Environmental Conservation	http://www.dec.ny.gov/chemical/81576.html

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Clean Air Status and Trends Network (CASTNET)	United States	--	United States Environment Protection Agency (EPA)	http://epa.gov/castnet/javaweb/index.html
Contaminated Sediments Regional Sediment Databases	Minnesota	--	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/contaminated-sediments/regional-sediment-databases.html
County Well Index	Minnesota	--	Minnesota Department of Health (MDH) Minnesota Geological Survey	http://www.health.state.mn.us/divs/eh/cwi/
Detroit Air Toxics Initiative (DATI)	Michigan	One-Time	Michigan Department of Environmental Quality	http://www.michigan.gov/deq/0,4561,7-135-3310_4105-139044--,00.html
Drinking Water Reporting System	Pennsylvania	--	Pennsylvania Department of Environmental Protection	http://www.drinkingwater.state.pa.us/dwrs/HTM/Welcome.html
Drinking Water System	Wisconsin	--	Wisconsin Department of Natural Resources	http://prodoasext.dnr.wi.gov/inter1/pws2\$.startup
Electronic Drinking Water Reporting	Ohio	--	Ohio Department of Natural Resources	http://www.epa.state.oh.us/ddagw/reporting.aspx
Emerging Chemical Surveillance Program	Great Lakes Basin	Annual	United States Environment Protection Agency (EPA)	http://www.epa.gov/greatlakes/monitoring/fish/health.html
Environmental Data Access: Air Quality	Minnesota	--	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/data/air-quality.html
Environmental Data Access: Surface Water Monitoring Data	Minnesota	--	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/data/surface-water-data.html
Environmental Data Access: Surface Water Monitoring Data	Minnesota	--	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/data/groundwater.html

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Environmental Monitoring and Assessment Program (EMAP): Regional Environmental Monitoring and Assessment Program (REMAP) Data	Great Lakes Basin	--	United States Environment Protection Agency (EPA)	http://www.epa.gov/emap/remap/html/five/data/index.html
Facility-Related Stream Surveys	Illinois	--	Illinois Environmental Protection Agency	http://www.epa.state.il.us/water/surface-water/river-stream-mon.html#sw3
Fish Contaminant Monitoring	Illinois	--	Illinois Environmental Protection Agency	http://www.epa.state.il.us/water/surface-water/river-stream-mon.html#sw6
Fish Contaminant Monitoring Program	Michigan	On-going	Michigan Department of Environmental Quality	http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-32393--,00.html
Fish Tissue Contaminant Monitoring Program	Indiana	Every 5 Year (Each Basin)	Indiana Department of Environmental Management	http://www.in.gov/idem/files/biostud_005fishtisscontammoprogram.pdf
Fish Tissue/Fish Consumption Advisory Data	Wisconsin	On-going	Wisconsin Department of Natural Resources	http://dnr.wi.gov/topic/surfacewater/monitoring.html
Great Lakes Environmental Database (GLENDA)	Great Lakes Basin	--	United States Environment Protection Agency (EPA)	http://www.epa.gov/grtlakes/monitoring/data_proj/glenda/index.html
Great Lakes Observing System	Great Lakes Basin	--	Integrated Ocean Observing System	http://glos.us/data-access
Great Lakes Regional Air Toxic Emissions Inventory	Great Lakes Basin	Multi-Year	Great Lakes Commission	http://www.glc.org/air/
Green Bay Mass Balance (GBMB) Study	Great Lakes Basin	One-Time	United States Environment Protection Agency (EPA)	http://www.epa.gov/grtlakes/monitoring/data_proj/gbmb/index.html
Ground Water Quality Characterization Program Data	Ohio	Occasional	Ohio Department of Natural Resources	http://www.epa.state.oh.us/ddagw/gwqcp.aspx

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Groundwater monitoring and assessment: Condition Groundwater Monitoring Data	Minnesota	Annual	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/water/water-types-and-programs/groundwater/groundwater-monitoring-and-assessment/condition-groundwater-monitoring.html
Groundwater monitoring and assessment: Statewide Baseline Study	Minnesota	One-Time	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/water/water-types-and-programs/groundwater/groundwater-monitoring-and-assessment/statewide-baseline-study.html
Groundwater Retrieval Network	Wisconsin	--	Wisconsin Department of Natural Resources	http://prodoasext.dnr.wi.gov/inter1/grn\$.startup
Harmful Algae Blooms Observing System	Regional	--	National Oceanic and Atmospheric Administration (NOAA)	http://habsos.noaa.gov/
Harmful Algal Bloom Data	Ohio	On-going	Ohio Department of Natural Resources	http://wwwapp.epa.ohio.gov/dsw/hab/toxin_monitoring.php
Historical Harmful Algal Bloom Data	Ohio	Occasional	Ohio Department of Natural Resources	http://www.epa.ohio.gov/Default.aspx?tabid=5159
Illinois Volunteer Lake Monitoring Program	Illinois	Occasional	Illinois Environmental Protection Agency	http://www.epa.state.il.us/water/vlmp/
Impaired Waters Data	Wisconsin	--	Wisconsin Department of Natural Resources	http://dnr.wi.gov/topic/surfacewater/monitoring.html
Indiana Public Water Supply Database	Indiana	--	Indiana Department of Environmental Management	https://myweb.in.gov/IDEM/DWW/
Intensive River Basin Surveys	Illinois	--	Illinois Environmental Protection Agency Illinois Department of Natural Resources (IDNR)	http://www.epa.state.il.us/water/surface-water/river-stream-mon.html#sw4
Lake Data	Wisconsin	--	Wisconsin Department of Natural Resources	http://dnr.wi.gov/topic/surfacewater/monitoring.html
Lake Michigan Monitoring Program	Great Lakes Basin	One-Time	Illinois Environmental Protection Agency	http://www.epa.gov/grtlakes/lmmb/index.html

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Lake Water Quality Assessment Monitoring Program	Michigan	Multi-Year	Michigan Department of Environmental Quality	http://www.michigan.gov/deq/0,4561,7-135-3313_3686_3731-195534--,00.html
Michigan Surface Water Information Management (MiSWIM) System	Michigan	--	Michigan Department of Environmental Quality	http://www.michigan.gov/deq/0,4561,7-135-3313_3686_43375---,00.html
Monitoring algae in streams	Minnesota	--	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/biological-monitoring/stream-monitoring/stream-monitoring-algae.html
Monitoring fish in streams	Minnesota	--	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/biological-monitoring/stream-monitoring/stream-monitoring-fish.html
National Atmospheric Deposition Program: Ammonia Monitoring Network (AMoN)	United States	Bi-weekly	Illinois State Water Survey	http://nadp.sws.uiuc.edu/amon/
National Atmospheric Deposition Program: Atmospheric Integrated Research Monitoring Network (AIRMoN)	United States	Daily	Illinois State Water Survey	http://nadp.sws.uiuc.edu/AIRMoN/
National Atmospheric Deposition Program: Atmospheric Mercury Network (AMNet)	United States	Hourly	Illinois State Water Survey	http://nadp.sws.uiuc.edu/amn/
National Atmospheric Deposition Program: Mercury Deposition Network	United States	Daily	Illinois State Water Survey	http://nadp.sws.uiuc.edu/MDN/

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
National Atmospheric Deposition Program: National Trends Network	United States	Weekly	Illinois State Water Survey	http://nadp.sws.uiuc.edu/NTN/
National Contaminant Biomonitoring Program Database	United States	--	United States Geological Survey (USGS)	http://www.cerc.usgs.gov/data/ncbp/ncbp.html
National Lakes Assessment Data	United States	Occasional	United States Environment Protection Agency (EPA)	http://water.epa.gov/type/lakes/NLA_data.cfm
National Sediment Quality Survey Database: 1980–1999	United States	Annual (1980-1999)	United States Environment Protection Agency (EPA)	http://water.epa.gov/polwaste/sediments/cs/nsidbase.cfm
National Water Information System	United States	--	United States Geological Survey (USGS)	http://waterdata.usgs.gov/nwis
Ohio Sport Fish Tissue Monitoring Program	Ohio	On-going	Ohio Department of Natural Resources	http://www.epa.state.oh.us/dsw/fishadvisory/sampledwaters.aspx
Open Lakes Trend Monitoring Program	Great Lakes Basin	On-going	United States Environment Protection Agency (EPA)	http://www.epa.gov/greatlakes/monitoring/fish/contaminant_concentrations.html
Pesticide Monitoring - Community Water Supply Wells Network	Illinois	Occasional	Illinois Environmental Protection Agency	http://www.epa.state.il.us/water/groundwater/ambient-monitoring.html
Pesticide Monitoring Subnetwork	Illinois	--	Illinois Environmental Protection Agency	http://www.epa.state.il.us/water/surface-water/river-stream-mon.html#sw2
River and Stream Volunteer Monitoring	Michigan	Occasional	Michigan Department of Environmental Quality	http://www.michigan.gov/deq/0,4561,7-135-3313_3686_3728-32396--,00.html
Rotating Integrated Basin Studies (RIBS)	New York	Every 5 Years	New York State Department of Environmental Conservation	http://www.dec.ny.gov/chemical/30951.html
Safe Drinking Water Information System	United States	--	United States Environment Protection Agency (EPA)	http://water.epa.gov/scitech/datait/databases/drink/sdwise/d/howtoaccessdata.cfm

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Sediment Chemistry Monitoring	Michigan	--	Michigan Department of Environmental Quality	http://www.michigan.gov/deq/0,4561,7-135-3313_3686_3728-32365--,00.html
Sediment Contaminant Monitoring Program	Indiana	Every 5 Year (Each Basin)	Indiana Department of Environmental Management	http://www.in.gov/idem/files/biostud_008sedcontammonprog.pdf
Sediment Effect Concentration Database	United States	--	United States Geological Survey (USGS)	http://www.cerc.usgs.gov/pubs/sedtox/sec.htm
Sport Fish Fillet Monitoring Program	Great Lakes Basin	--	United States Environment Protection Agency (EPA)	http://www.epa.gov/greatlakes/monitoring/fish/sport.html
Statewide Biological and Water Quality Monitoring and Assessment	Ohio	Every 5 years (each Ohio EPA district)	Ohio Department of Natural Resources	http://epa.ohio.gov/dsw/bioassess/ohstrat.aspx
STORET Data Warehouse	United States	--	United States Environment Protection Agency (EPA)	http://www.epa.gov/storet/dw_home.html
Stream Biomonitoring Program	New York	--	New York State Department of Environmental Conservation	http://www.dec.ny.gov/chemical/23847.html
Stream Data	Wisconsin	--	Wisconsin Department of Natural Resources	http://dnr.wi.gov/topic/surfacewater/monitoring.html
Stream Quality Monitoring	Ohio	On-going	Ohio Department of Natural Resources	http://www.dnr.state.oh.us/ScenicRivers/SQM/tabid/2550/Default.aspx
Toxic Monitoring Sites in Pennsylvania	Pennsylvania	On-going	Pennsylvania Department of Environmental Protection	http://www.dep.state.pa.us/dep/deputate/airwaste/qa/toxics/sites.htm
Toxicity Testing Program	Illinois	--	Illinois Environmental Protection Agency	http://www.epa.state.il.us/water/surface-water/river-stream-mon.html#sw5
Unregulated Contaminant Monitoring Rule (UCMR)	United States	Every 5 years	United States Environment Protection Agency (EPA)	http://water.epa.gov/lawsregs/rulesregs/sdwa/ucmr/
Volatile Organic Compounds Monitoring Data	New York	Multi-Year	New York State Department of Environmental Conservation	http://www.dec.ny.gov/chemical/8538.html

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Water Chemistry Monitoring	Michigan	--	Michigan Department of Environmental Quality	http://www.michigan.gov/deq/0,4561,7-135-3313_3686_3728-32361--,00.html
Water Inventory Program	Ohio	--	Ohio Department of Natural Resources	http://www.dnr.state.oh.us/tabid/4237/default.aspx
Wetlands Data	Wisconsin	--	Wisconsin Department of Natural Resources	http://dnr.wi.gov/topic/surfacewater/monitoring.html
Wisconsin Beach Monitoring Program	Wisconsin	--	Wisconsin Department of Natural Resources	http://dnr.wi.gov/topic/surfacewater/monitoring.html

A.3 Human Exposure

Canada

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Canadian Health Measure Survey (CHMS)	Canada	Biennial	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5071&Item_Id=129548&lang=en
Canadian Human Milk Survey (HMS)	Canada	Occasional	Health Canada	http://www.hc-sc.gc.ca/fn-an/securit/chem-chim/milk-survey-lait-enquete-eng.php
Canadian Total Diet Study	Canadian Cities	Occasional	Health Canada	http://www.hc-sc.gc.ca/fn-an/surveill/total-diet/index-eng.php
Contaminants in Human Tissues Survey	Great Lakes Basin	--	Health Canada Assembly of First Nations Chiefs of Ontario	http://www.chiefs-of-ontario.org/sites/default/files/files/chtfin2.pdf
Environmental Exposure Estimates and Profile	Canada	--	CAREX Canada	http://www.carexcanada.ca/en/
First Nations Biomonitoring Initiative	Canada	--	Health Canada	http://www.hc-sc.gc.ca/fniah-spnia/promotion/research-recherche/index-eng.php
Maternal-Infant Research on Environmental Chemicals (MIREC)	Canadian Cities	Multi-Year	Health Canada	http://www.mirec-canada.ca/

United States

Data Sources	Geographic Scope	Temporal Scope	Affiliated Organization(s)	Link
Consolidated Human Activity Database (CHAD)	United States	--	US Environment Protection Agency (EPA)	http://www.epa.gov/chadnet1/index.html
Human Exposure Measurements: National Human Exposure Assessment Survey (NHEXAS)	United States (Selected Regions)	Occasional	Centers for Disease Control and Prevention (CDC)	http://www.epa.gov/heasd/edrb/nhexas.html
National Air Toxics Assessments	United States	Occasional	US Environment Protection Agency (EPA)	http://www.epa.gov/ttn/atw/natamain/
National Children Survey (NCS)	United States	Multi-Year	Centers for Disease Control and Prevention (CDC)	http://www.nationalchildrensstudy.gov/about/overview/Pages/default.aspx
National Health and Nutrition Examination Survey (NHANES)	United States	Biennial	Centers for Disease Control and Prevention (CDC)	http://www.cdc.gov/nchs/nhanes.htm
Total Diet Study	United States	Quarterly	U.S. Food and Drug Administration (FDA)	http://www.fda.gov/Food/FoodScienceResearch/TotalDietStudy/ucm184232.htm

A.4 Human Health Outcomes

Canada

Data Sources	Geographic Coverage	Temporal Coverage	Affiliated Organization(s)	Link
Aboriginal Children's Survey (CS)	Canada	One-Time	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5108&lang=en&db=imdb&adm=8&dis=2
Aboriginal Peoples Survey (APS)	Canada	Every 5 years	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3250&lang=en&db=imdb&adm=8&dis=2#b4
BORN Information System (BIS)	Ontario	--	Better Outcomes Registry & Network Ontario	http://www.bornontario.ca/data/data-collection
Canada Health Survey	Canada	One Time	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3217&lang=en&db=imdb&adm=8&dis=2#a1
Canadian Cancer Registry (CCR)	Canada	Annual	<u>Nation-wide Dataset:</u> Statistics Canada <u>Ontario Dataset:</u> Institute for Clinical Evaluative Sciences (ICES)	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3207&lang=en&db=imdb&adm=8&dis=2#a2
Canadian Community Health Survey	Canada	Annual	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3226&lang=en&db=imdb&adm=8&dis=2#a2
Canadian Coroner and Medical Examiner Database	Canada	Annual	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5125&lang=en&db=imdb&adm=8&dis=2
Canadian Healthy Infant Longitudinal Development (CHILD) Survey	Canada	One-Time	Canadian Institutes of Health Research (CIHR)	http://www.canadianchildstudy.ca/overview.html

Data Sources	Geographic Coverage	Temporal Coverage	Affiliated Organization(s)	Link
Canadian Nosocomial Infection Surveillance Program	Canada	--	Public Health Agency of Canada (PHAC)	http://www.phac-aspc.gc.ca/nois-sinp/survprog-eng.php
Canadian Survey on Disability	Canada	Every 5 years	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3251&Item_Id=133011&lang=en
Cardiac Care Network Data	Canada	Annual	Institute for Clinical Evaluative Sciences (ICES)	http://www.ices.on.ca/webpage.cfm?site_id=1&org_id=26&morg_id=0&gsec_id=5314&item_id=5322
C-EnterNet	Canada	--	Public Health Agency of Canada (PHAC)	http://www.phac-aspc.gc.ca/c-enternet/index-eng.php
Dataset linking the admission records of delivering mothers and their newborns	Canada	Annual	Institute for Clinical Evaluative Sciences (ICES)	http://www.ices.on.ca/webpage.cfm?site_id=1&org_id=26&morg_id=0&gsec_id=5314&item_id=5322
Discharge Abstract Database (DAD)	Canada (Ontario)	Annual	<u>Nation-wide Dataset:</u> Canadian Institute for Health Information (CIHI) <u>Ontario Dataset:</u> Institute for Clinical Evaluative Sciences (ICES)	http://www.cihi.ca/CIHI-external/internet/en/document/types-of-care/hospital+care/acute+care/dad_metadata http://www.ices.on.ca/webpage.cfm?site_id=1&org_id=26&morg_id=0&gsec_id=5314&item_id=5322
Enhanced Surveillance for Chronic Disease Program	Canada	--	Public Health Agency of Canada (PHAC)	http://www.phac-aspc.gc.ca/cd-mc/es-sa/index-eng.php
First Nations Regional Longitudinal Health Survey	Canada	One-Time	Health Canada First Nations Information Governance Centre	http://www.rhs-ers.ca/node/11
Hospital Morbidity Database	Canada (Ontario)	Biennial	Canadian Institute for Health Information (CIHI)	http://www.cihi.ca/cihi-external/internet/en/document/types-of-care/hospital+care/acute+care/hmdb_metadata

Data Sources	Geographic Coverage	Temporal Coverage	Affiliated Organization(s)	Link
Maternity Experiences Survey (MES)	Canada	One Time	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5019&Item_Id=22024
National Ambulatory Care Reporting System	Canada (Ontario)	Annual	<p><u>Nation-wide Dataset:</u> Canadian Institute for Health Information (CIHI)</p> <p><u>Ontario Dataset:</u> Institute for Clinical Evaluative Sciences (ICES)</p>	<p>http://www.cihi.ca/CIHI-ext-portal/internet/en/document/types+of+care/hospital+care/emergency+care/NACRS_METADATA</p> <p>http://www.ices.on.ca/webpage.cfm?site_id=1&org_id=26&morg_id=0&gsec_id=5314&item_id=5322</p>
National Enteric Surveillance Program	Canada	--	Public Health Agency of Canada (PHAC)	http://www.nml-lnm.gc.ca/NESP-PNSME/index-eng.htm
National Population Health Survey (NPHS)	Canada	Biennial	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3225&Item_Id=1824&lang=en
Ontario Cancer Registry	Canada	Annual	Institute for Clinical Evaluative Sciences (ICES)	http://www.ices.on.ca/webpage.cfm?site_id=1&org_id=26&morg_id=0&gsec_id=5314&item_id=5322
Ontario Child Health Study	Ontario	Occasional	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3824&Item_Id=1440&lang=en#a2
Ontario Diabetes Database	Canada	Annual	Institute for Clinical Evaluative Sciences (ICES)	http://www.ices.on.ca/webpage.cfm?site_id=1&org_id=26&morg_id=0&gsec_id=5314&item_id=5322

Data Sources	Geographic Coverage	Temporal Coverage	Affiliated Organization(s)	Link
Ontario Drug Benefit Claims	Canada	Bi-monthly	Institute for Clinical Evaluative Sciences (ICES)	http://www.ices.on.ca/webpage.cfm?site_id=1&org_id=26&morg_id=0&gsec_id=5314&item_id=5322
Ontario Health Insurance Plan Claims Database	Canada	Bi-monthly	Institute for Clinical Evaluative Sciences (ICES)	http://www.ices.on.ca/webpage.cfm?site_id=1&org_id=26&morg_id=0&gsec_id=5314&item_id=5322
Pediatric Oncology Group of Ontario Network Information System	Ontario	--	Pediatric Oncology Group of Ontario (POGO)	http://www.pogo.ca/privacy/requesting-data/
Primary Health Reporting System	Canada	--	Canadian Institute for Health Information (CIHI)	http://www.cihi.ca/CIHI-ext-portal/internet/EN/TabbedContent/types+of+care/primary+health/cihi006583
Registry of Canadian Stroke Network	Canada	Occasional	Institute for Clinical Evaluative Sciences (ICES)	http://www.ices.on.ca/webpage.cfm?site_id=1&org_id=26&morg_id=0&gsec_id=5314&item_id=5322
Respiratory Virus Detection Surveillance System reports	Canada	--	Public Health Agency of Canada (PHAC)	http://www.phac-aspc.gc.ca/bid-bmi/dsd-dsm/rvdi-divr/index-eng.php
Survey of Neurological Conditions in Institutions in Canada	Canada	One Time	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5187&lang=en&db=imdb&adm=8&dis=2#b4
Survey on Living with Chronic Diseases in Canada	Canada	Biennial	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5160&lang=en&db=imdb&adm=8&dis=2#a2

Data Sources	Geographic Coverage	Temporal Coverage	Affiliated Organization(s)	Link
Vital Statistics - Death Database	Canada	Annual	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3233&lang=en&db=imdb&adm=8&dis=2
Vital Statistics -Birth Database	Canada	Annual	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3234&lang=en&db=imdb&adm=8&dis=2
Vital Statistics - Stillbirth Database	Canada	Annual	Statistics Canada	http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3234&lang=en&db=imdb&adm=8&dis=2
West Nile Virus Surveillance Information	Canada	Annual	Public Health Agency of Canada (PHAC)	http://www.phac-aspc.gc.ca/wnv-vwn/index-eng.php

United States

Data Sources	Geographic Coverage	Temporal Coverage	Affiliated Organization(s)	Link
Behavioral Risk Factor Surveillance System (BRFSS): Asthma Call-back Survey (ACBS)	United States	Annual	Centers for Disease Control and Prevention (CDC)	http://www.cdc.gov/brfss/acbs/index.htm
Behavioral Risk Factor Surveillance System (BRFSS): Data	United States	Annual	Centers for Disease Control and Prevention (CDC)	http://www.cdc.gov/brfss/annual_data/annual_data.htm#2001
Birth Defects	Michigan	Annual	Michigan Department of Community Health	http://www.michigan.gov/mdch/0,4612,7-132-2944_4670--,00.html
Chronic Disease and Injury Control Data: Disability Health	Michigan	--	Michigan Department of Community Health	http://www.michigan.gov/mdch/0,4612,7-132-2940_2955_54051---,00.html
Chronic Disease and Injury Control Data: Asthma	Michigan	--	Michigan Department of Community Health	http://www.michigan.gov/mdch/0,4612,7-132-2940_2955_48758---,00.html
Emergency Medical Services (EMS) Data Reporting System	Illinois	--	Illinois Department of Public Health (IDPH)	http://app.idph.state.il.us/emsrpt/
Family Health Survey	Wisconsin	Occasional	Wisconsin Department of Health Services	http://www.dhs.wisconsin.gov/stats/prevyrsreportsfhs.htm
Health Care Statistics: Leading hospitalizations	Michigan	--	Michigan Department of Community Health	http://www.michigan.gov/mdch/0,4612,7-132-2944_5324_43671---,00.html
Health Care Statistics: Medical Procedures	Michigan	--	Michigan Department of Community Health	http://www.michigan.gov/mdch/0,4612,7-132-2944_5324_58392---,00.html

Data Sources	Geographic Coverage	Temporal Coverage	Affiliated Organization(s)	Link
Health Care Statistics: Preventable hospitalizations	Michigan	--	Michigan Department of Community Health	http://www.michigan.gov/mdch/0,4612,7-132-2944_5324_6867---,00.html
Health Facilities Statistics: Ambulatory Surgery Center Reports	Pennsylvania	Annual	Pennsylvania Department of Health	http://www.portal.state.pa.us/portal/server.pt?open=514&objID=596751&mode=2
Health Facilities Statistics: Hospital Reports	Pennsylvania	Annual	Pennsylvania Department of Health	http://www.portal.state.pa.us/portal/server.pt?open=514&objID=596752&mode=2
Hospital Discharge Data	Illinois	--	Illinois Department of Public Health (IDPH)	http://app.idph.state.il.us/hospitaldischarge/
Hospital Guide & Public Data (Inpatient, Aggregated Data)	Indiana	Annual	Indiana State Department of Health	http://www.state.in.us/isdh/20624.htm
IPLAN Data System	Illinois	Annual	Illinois Department of Public Health (IDPH)	http://app.idph.state.il.us/iplandatasystem.asp?menu=1
Maternal and Child Health Data: Birth Defects/Early Hearing Detection and Intervention	Michigan	--	Michigan Department of Community Health	http://www.michigan.gov/mdch/0,1607,7-132-2942_41657-162300--,00.html
Maternal and Child Health Data: Newborn Screening	Michigan	--	Michigan Department of Community Health	http://www.michigan.gov/mdch/0,1607,7-132-2942_4911_21428-12856--,00.html
Minnesota Public Health Data Access	Minnesota	--	Minnesota Department of Health (MDH)	https://apps.health.state.mn.us/mndata/

Data Sources	Geographic Coverage	Temporal Coverage	Affiliated Organization(s)	Link
National Ambulatory Medical Care Survey (NAMCS)	United States	Annual	Centers for Disease Control and Prevention (CDC)	http://www.cdc.gov/nchs/ahcd.htm
National Childhood Lead Poisoning Data	United States	Annual	Centers for Disease Control and Prevention (CDC)	http://www.cdc.gov/nceh/lead/data/national.htm
National Diabetes Surveillance System	United States	Annual	Centers for Disease Control and Prevention (CDC)	http://apps.nccd.cdc.gov/DDTSTRS/default.aspx
National Health Interview Survey (NHIS)	United States	Annual	Centers for Disease Control and Prevention (CDC)	http://www.cdc.gov/nchs/nhis.htm
National Hospital Care Survey (NHCS)	United States	--	Centers for Disease Control and Prevention (CDC)	http://www.cdc.gov/nchs/nhcs/about_nhcs.htm
National Hospital Discharge Survey	United States	Annual	Centers for Disease Control and Prevention (CDC)	http://www.cdc.gov/nchs/nhds/nhds_questionnaires.htm
National Maternal and Infant Health Survey (NMIHS)	United States	Occasional	Centers for Disease Control and Prevention (CDC)	http://www.cdc.gov/nchs/nvss/nmihs.htm
National Outbreak Reporting System (NORS)	United States	On-going	Centers for Disease Control and Prevention (CDC)	http://www.cdc.gov/nors/about.html
National Program of Cancer Registries	United States	Annual	Centers for Disease Control and Prevention (CDC) Cancer Statistics can be accessed through state-level cancer registry programs	http://www.cdc.gov/cancer/npcr/

Data Sources	Geographic Coverage	Temporal Coverage	Affiliated Organization(s)	Link
National Vital Statistics System (NVSS)	United States	Annual	Centers for Disease Control and Prevention (CDC) Vital Statistics can also be accessed through state-level health department	http://www.cdc.gov/nchs/nvss.htm
New York State Community Health Indicator Reports	New York	Multi-Year	New York State Department of Health	http://www.health.ny.gov/statistics/chac/indicators/
New York State County/ZIP Code Perinatal Data Profile	New York	Multi-Year	New York State Department of Health	http://www.health.ny.gov/statistics/chac/perinatal/
Ohio Department of Health Information Warehouse	Ohio	--	Ohio Department of Health	http://dwhouse.odh.ohio.gov/
Pediatric Nutrition Surveillance System (PedNSS) and Pregnancy Surveillance System (PNSS)	United States	--	Centers for Disease Control and Prevention (CDC)	http://www.cdc.gov/pednss/
Pregnancy Risk Assessment Monitoring System (PRAM)	United States	--	Centers for Disease Control and Prevention (CDC)	http://www.cdc.gov/prams/
Systematic Tracking of Elevated Lead Levels & Remediation	United States	--	Centers for Disease Control and Prevention (CDC)	http://www.cdc.gov/nceh/lead/data/stellar.htm

Data Sources	Geographic Coverage	Temporal Coverage	Affiliated Organization(s)	Link
The Joint Canada/United States Survey of Health	Canada/United States	One-time	Centers for Disease Control and Prevention (CDC) Statistics Canada	http://www.cdc.gov/nchs/nhis/jcush.htm http://www5.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=82M0022XIE&lang=eng
Wisconsin Interactive Statistics on Healthcare: Birth-Count	Wisconsin	Annual	Wisconsin Department of Health Services	http://www.dhs.wisconsin.gov/wish/main/wis_births/wis_births_home.htm
Wisconsin Interactive Statistics on Healthcare: Fertility (Birth Rates)	Wisconsin	Annual	Wisconsin Department of Health Services	http://www.dhs.wisconsin.gov/wish/main/fertility/fertility_home.htm
Wisconsin Interactive Statistics on Healthcare: Infant Mortality	Wisconsin	Annual	Wisconsin Department of Health Services	http://www.dhs.wisconsin.gov/wish/main/inf_mort/inf_mort_home.htm
Wisconsin Interactive Statistics on Healthcare: Low Birth weight	Wisconsin	Annual	Wisconsin Department of Health Services	http://www.dhs.wisconsin.gov/wish/main/lbw/lbw_home.htm

A.5 Spatial Data

Canada

Data Sources	Geographic Coverage	Temporal Coverage	Affiliated Organization(s)	Link
Agricultural Resource Inventory (ARI)	Ontario	--	Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA)	http://www.omafra.gov.on.ca/english/landuse/gis/ari_1983.htm
Ambient Groundwater Geochemistry Data for Southwestern Ontario, 2007-2010	Southwestern Ontario	--	Ontario Ministry of Northern Development and Mines	http://www.geologyontario.mndm.gov.on.ca/
Bedrock Geology of Ontario (MRD126)	Ontario	--	Ontario Ministry of Northern Development and Mines	http://www.geologyontario.mndm.gov.on.ca/mndmaccess/mndm_dir.asp?type=pub&id=MRD126-REV1
Bedrock Topography and Overburden Thickness of Southern Ontario (MRD207)	Ontario	--	Ontario Ministry of Northern Development and Mines	http://www.geologyontario.mndm.gov.on.ca/mndmaccess/mndm_dir.asp?type=pub&id=MRD207
Geobase	Canada	--	Canadian Council on Geomatics	http://www.geobase.ca/geobase/en/index.html
GeoGratis	Canada	--	National Resources Canada (NRCan)	www.GeoGratis.gc.ca/

Data Sources	Geographic Coverage	Temporal Coverage	Affiliated Organization(s)	Link
Ontario Forest Resources Inventory	Ontario	--	Ontario Ministry of Natural Resources,	http://www.mnr.gov.on.ca/en/Business/Forests/2ColumnSubPage/199556.html
Ontario Hydro Network (OHN)	Ontario	--	Ministry of Natural Resources	http://geo1.scholarsportal.info/#r/search/_queries@=Ontario%20Hydro%20Network%20;&fields@=&sort=relevance
Rare Species Occurrence Data in Ontario	Ontario	--	Natural Heritage Information Centre, Ontario Ministry of Natural Resources	http://nhic.mnr.gov.on.ca/MNR/nhic/species/shapefile.cfm
Soil Survey Complex (Southern Ontario Soil Survey) (Version 1.0)	Southern Ontario	--	Ontario Ministry of Agriculture and Rural Affairs (OMAFRA)	http://geo2.scholarsportal.info/#r/search/_queries@=Soil%20Survey%20Complex;&fields@=&sort=relevance
Water Resources Information Program (WRIP)	Ontario	--	Ontario Ministry of Natural Resources	http://www.mnr.gov.on.ca/en/Business/WRIP/index.html

United States

Data Sources	Geographic Coverage	Temporal Coverage	Affiliated Organization(s)	Link
Department of Natural Resources Data Deli	Minnesota	--	Minnesota Department of Natural Resources	http://deli.dnr.state.mn.us/
Environmental Data Access: Spatial Data	Minnesota	--	Minnesota Pollution Control Agency	http://www.pca.state.mn.us/index.php/data/spatial-data.html
Geospatial One-Stop Portal	United States	--	United States Government	http://geo.data.gov/geoportal/catalog/main/home.page
GIS Atlas for Indiana	Indiana	--	Indiana Geological Survey	http://inmap.indiana.edu/dload_page/reference.html
Great Lakes Information Network Maps & GIS	Great Lakes Basin	--	Great Lakes Information Network	http://gis.glin.net/
Illinois Natural Resources Geospatial Data Clearinghouse	New York	--	Illinois State Geological Survey	http://www.isgs.uiuc.edu/nsdihome/
Michigan Geographic Data Library	Michigan	--	Michigan Department of Information Technology	http://www.mcgi.state.mi.us/mgdl/?rel=ext&action=sext

Data Sources	Geographic Coverage	Temporal Coverage	Affiliated Organization(s)	Link
National Historical Geographic information System (NHGIS)	United States	--	Minnesota Population Center	https://www.nhgis.org/
National Resources Inventory	United States	--	U.S. Department of Agriculture	http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/nri/
New York State GIS Clearinghouse	New York	--	New York State Office of Cyber Security	http://gis.ny.gov/
Pennsylvania Spatial Data Access (PASDA)	Pennsylvania	--	The Pennsylvania State University	http://www.pasda.psu.edu/
Soil Survey Geographic (SSURGO) Database	United States	--	United States Department of Agriculture	http://soils.usda.gov/survey/geography/ssurgo/
The National Map	United States	--	US Geological Survey	http://nationalmap.gov/
Wisconsin Spatial Data Repository	Wisconsin	--	Wisconsin Department of Administration - Wisconsin Geographic Information Office	http://gio.wi.gov/Projects/tabid/226/Default.aspx

Appendix B – Expert Consultation Participants and Template Interview Questions

B.1 Expert Consultation Participants

Participant	Organization
Dr. Judy Qualters	Centers for Disease Control and Prevention (CDC)
Jeff Percy	Centers for Disease Control and Prevention (CDC)
Dr. Carl Richard	U.S. Environmental Protection Agency
Tom Hollenhorst	U.S. Environmental Protection Agency
Dr. Alan Abelson	University of Toronto
Dr. Doug Manuel	Institute for Clinical Evaluative Sciences (ICES)
Dr. Laura Rosella	Institute for Clinical Evaluative Sciences (ICES)
Dr. Ray Copes	Public Health Ontario
Dr. Susan Elliott	University of Waterloo
Dr. Todd Howell	Ontario Ministry of Environment
Dr. Paul Demers	Cancer Care Ontario
Dr. David Buckeridge	McGill University

B.2 Template Interview Questions

1. Existing Environmental and Human Health Databases in the United States/Canada

- What are some of key environmental and human health databases (especially related to the Great Lakes Area) in United States/Canada?
- What types of data are being collected?
- Who are the key stakeholders group involved in the collection/maintenance of data?
- Who has access to the data and how can the data be accessed?

2. Existing Environmental-Human Health Integration Initiatives

- Current Status of the Initiatives
- What types of datasets collected?
- Who has access to the data and how can the data be accessed?
- What are some of strengths and weaknesses of the initiatives?
- What are some barriers and challenges to integration?
- Are there any potential opportunities for Great Lakes Human Health and Environmental Database Integration Project to leverage on the existing initiatives?
- What are some of key environmental databases (especially related to the Great Lakes Area) in United States?
- What types of data are being collected?
- Who are the key stakeholders group involved in the collection/maintenance of data?
- Who has access to the data and how can the data be accessed?
- Can the information be easily linked to public health data?

3. General - Integration of Environmental and Health Data

- Had there been any other attempts to integrate large scale environmental and health dataset in the United States/Canada?
- Had there been any other attempts to integrate and to facilitate the sharing of data across multiple states?
- Had there been any other attempts to integrate and to facilitate the sharing of data between Canada and the United States?