

Environmental Disaster Management in the Great Lakes:
To What Extent are Governments in the Region Prepared?

by

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Abstract

This thesis examines the current state of environmental disaster management in the Great Lakes region of North America. The purpose of this study is to understand to what extent are governments prepared to manage environmental disasters in the region. The study reviews governance institutions and agreements related to environmental disaster management. A qualitative methodology using open-ended, semi structured interviews to explore and examine what exists and what is missing in terms of arrangements related to environmental disaster management within the Great Lakes region. The findings from this study highlight the need for a definition of environmental disaster, some transboundary thinking, policy work and coordination related potential environmental disasters management in the region. While some environmental disasters are local and national, there is a need for some transboundary mitigation, preparedness and capacity-building related to potential environmental disasters in the region among federal and regional institutions generally and specifically related to the Great Lakes Water Quality Agreement.

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1.0 Introduction

Natural and man-made disasters are threatening countries and causing fatal damages to the economy, the environment and the livelihood and well-being of people across the globe (Zhang and Huang, 2018). Scholars in many disciplines and practitioners in several fields have realized the significance of natural and environmental disasters for decades. The study of environmental disasters is interdisciplinary and requires a broad range of knowledge and research to understand the natural and human dimensions of disasters. Some environmental disasters are known to be directly caused by human actions and behavior, while others are beyond human control and understanding. Reducing associated risks with existing and potential hazards that threaten people and societies is the ultimate goal of disaster management (O'Brien et al., 2006) at local, regional and international scales.

Disaster management is based on the belief that human intervention and action can help humans mitigate and adapt to disasters. There is an extensive scholarly and practitioner literature related to disaster management, as virtually all jurisdictions have to grapple with environmental disasters. Yet, capacity for human intervention, 'management' and action remain limited in the context of uncertainty related to many types of natural disasters. In addition, there are a wide range of government, non-government and private sector actors involved in environmental disaster management.

This thesis focuses on government-led regimes related to environmental disaster management in the Great Lakes region. The introduction covers the significance of disasters globally, in Canada and the United States, and in the Great Lakes region. It introduces key concepts and dimensions of environmental disasters; outlines the objectives of this research project; the central research questions; and provides an overview of the structure of the thesis.

Prior to a focus on environmental disasters in the Great Lakes, the researcher had an interest of exploring environmental disaster management in the Red Sea region in Saudi Arabia. The goal was to investigate transboundary and national government arrangements related to environmental disasters in the Red Sea within the borders of the Kingdom of Saudi Arabia, Egypt and Sudan. A comparative research approach was considered to study both regions and compare government arrangements. However, due to the lack of publically available government documents and some government restrictions on data related to environmental disasters management in the Red Sea, a focus on environmental disaster management in that region and a comparative analysis was not feasible to conduct. Preliminary research indicated that there was not a lot of research on this topic in the Great Lakes region. Therefore, this thesis focuses on environmental disaster management in the Great Lakes region of North America providing some research foundations for possible comparative research in the future.

1.1 Background and Significance of Environmental Disasters

Every year, millions of people are affected by natural disasters across the world (Harrison et al., 2015). In 2018, approximately 3.9 billion people - close to half of the world's population - had experienced the negative consequences of natural disasters (CRED, 2019). Worldwide, the most severe disaster of 2018 was the earthquake that occurred in Indonesia and resulted in 4,340 people being dead or missing (CRED, 2019). In 2017, 335 natural disasters such as tropical storms, flooding and earthquakes occurred globally, which resulted in 9,697 deaths, impacted 95.1 million people and caused an economic damage of \$335 billion US dollars (Davis, 2019). In fact, natural disasters cause tremendous impacts on countries including human mortalities and economic damages. In the first 10 years of the 21st century, a loss of \$113 billion on average per year occurred due to natural disasters in the world (Gallagher and Hartley, 2017).

According to the International Disaster Database-Centre for Research on the Epidemiology of Disasters (CRED), there were 6,873 natural disasters that caused \$1.35 million deaths between 1994 to 2013, globally (CRED, 2015). Some 53% of these disasters happened in high and upper-middle income countries and resulted in 32% of all deaths. Some 44% of the disasters in this period occurred in low and lower-middle income countries and caused 68% of all deaths. Asia recorded the highest number of people affected by disasters among continents with a total of 2,778 disasters, which caused 841,000 deaths and affected 3.8 billion people. The United States and China reported the majority of disasters among countries in the same period of time (CRED, 2015). The CRED report further highlights the frequency of disasters from 1994 to 2013. Floods came in the first place with 43% of all disasters impacting 2.5 billion people; earthquakes are the deadliest type of disasters resulting in approximately 750,000 deaths; and storms came in second killing more than 244,000 people globally from 1994-2013 (CRED, 2015).

In the United States, over 200 natural disasters occurred between 1980 and 2016, many in coastal communities (Bleemer and Klaauw, 2019). Hurricanes and tornados are some of the most prevalent natural disasters. Some 1200 to 1300 tornados occur in the United States each year (Harrison et al., 2013). Hurricane Katrina was the most fatal and expensive storm. It killed thousands of people and demolished large areas of New Orleans (Boustan et al., 2012; Bleemer and Klaauw, 2019). Katrina hit the Gulf Coast of the United States on August 29, 2005, and brought disastrous damages to many communities in Mississippi and Louisiana. It was ranked as a category 3-hurricane according to the Saffir-Simpson Scale (Brunkard et al., 2008); killed 1,833 people and resulted in a property damage of approximately \$108 billion (Gallagher and Hartley 2017). Moreover, flooding from the hurricane covered about 85% of New Orleans (Gallagher and Hartley, 2017). In comparison, Hurricane Audrey of 1957 was considered the most fatal hurricane in the United States prior to Katrina with a death toll of 416 people (Brunkard et al.,

2008). And Hurricane Harvey alone caused a damage of \$180 billion dollars to the economy of Huston, Texas (Davis, 2019).

In addition to major natural disasters such as hurricanes, there have been several important man-made environmental disasters including the Exxon Valdez oil spill near Alaska in 1989 and the more recent Deepwater Horizon oil spill in the Gulf of Mexico in 2010. The Deepwater Horizon oil spill is considered one of the most devastating environmental disasters and the biggest ecological disaster in US history (Müller, 2018). An explosion occurred within the Deepwater Horizon oil rig owned and operated by offshore-oil-drilling company Transocean and leased by oil company BP (British Petrochemical Corporation) in April 2010. The catastrophe resulted in 11 fatalities, many human injuries, a spill of 5 million barrels of oil into the Gulf of Mexico over a period of three months, and massive ecological damages affecting more than 600 miles of shorelines of the Gulf coast (Buckingham-Howes et al., 2017). Consequently, fundamental impacts on the economy, environment and wildlife existed and 33% of the coastline was shut down for shellfish harvesting and fishing (Buckingham-Howes et al., 2017).

Canada has also had its share of environmental disasters. It faces potential risks of natural and human made hazards as a result of its different climates, varied environments and huge area (Joakim and Doberstein, 2013). Being the second largest country in the world with huge geography and various climates, massive disaster challenges and climate threats put Canada at risk (Agrawal and Cox, 2019). According to a report from Statistics Canada, 12.4 million Canadians stated that they have experienced a major disaster or emergency in their lifespan and 73% of them reported that their experience was significant to the point where it affected their daily schedule (Ibrahim, 2016).

It is estimated that roughly 60 tornados hit Canada each year, compared to 1200 to 1300 in the United States (Harrison et al., 2013), although comparatively not a large number, storms and disasters from wind and rain have serious consequences across Canada. Canada has faced

serious floods in all provinces and regions in the last 150 years, making flooding the most common natural hazard in the country. Some 240 flood disasters occurred between 1900 and 2005, which led to hundreds of fatalities and billions of dollars in damages (Doberstein et al., 2019). The 2013 Calgary flood is considered one of the worst environmental disasters for the city in 80 years, which resulted in an evacuation of 75,000 people, a damage of 3,000 homes and buildings and an insured loss of \$6 billion Canadian dollars (Thistlethwaite and Henstra 2017; Doberstein et al., 2019). In Manitoba, 113 natural disasters such as storms, wildfires, droughts and floods occurred from 1904 to 2017 (Haque et al., 2019).

The province of Alberta has experienced one of most severe wildfire disasters in the country. On May 1, 2016, the Fort McMurray wildfire started in Alberta and spread to Saskatchewan, which burned a total land of 589,995 hectares. It was ranked among the most extreme disasters in the history of Canada, which resulted in a total economic damage of approximately \$6 billion, an evacuation of 88,000 people and damaged 2,400 houses and businesses (Mamuji and Rozdilsky, 2019). Additionally, between 1844 and 2002, 25 ice storms occurred in Southern Ontario (Rajaram et al., 2016). The 1998 Ice Storm is considered the most disastrous one and it resulted in a total of 47 deaths, 28 in Canada and 19 in the United States (Rajaram et al., 2016).

Although death tolls due to natural disasters have decreased in Canada recently, the economic and recovery costs and social impacts have increased tremendously (Joakim and Doberstein, 2013). According to a projection study by Godsoe et al., Canada needs to prevent 88 hazards to turn into disasters, stop disaster evacuation of 556,000 people, reduce disaster death rate nearly to zero, avoid 4,700 disaster injuries and prevent \$92 billion in disaster losses by 2030 (2019).

In addition to the significance of natural and environmental disasters within countries, there is growing concern about the potential for more disasters related to climate change. The

relationship between climate change and natural disasters is well-documented (Van Aalst, 2006). Climate change causes a rise in earth's temperature, which results in more heat waves and wildfires. Also, it increases the frequency of intense precipitation incidents, which increases the probability and frequency of landslides and floods. Climate change has been shown to have played a major role in the frequency and intensity of tropical cyclones in the Atlantic region in previous 30 years (Van Aalst, 2006). Furthermore, several scientists predict that the number of disasters such as hurricanes will increase as a result of climate change (Gallagher and Hartley, 2017). Risk of flooding has increased due to extreme precipitation in the late period of winter and spring. These impacts have already started and might become more intense in the future. There is some evidence that flooding in particular will become a very significant environmental problem in the Great Lakes region related to warmer water and air temperatures and a decrease of ice coverage in the lakes (Bartolai et al., 2015).

This introduction to environmental disasters highlights their historical and increasing significance. It outlines the significant human and ecological costs of environmental disasters. Environmental disasters have been studied in many jurisdictions, often in response to a major disaster. Canada and the United States have had their share of environmental disasters. Some of these disasters are due to forces of nature and others are due to human consequences. Others are predictable with climate and weather technologies and some related to human error and cumulative stressors and threats. Most involve responses from a wide range of organizations and actors from the government, non-government and private sectors.

This thesis examines environmental disaster management in the Great Lakes region of North America with a particular focus on government regimes in place to manage regional environmental disasters. While this region is not typically thought of as being high risk related to environmental disasters, and some may think that environmental disasters are not commonplace or of imminent risk in this region, the literature review and history of environmental disasters in

the Great Lakes region indicate the region has been subject to several different types of environmental disasters. It also highlights the increasing significance of disaster management even in traditionally low risk regions. The uncertainty and risks associated with climate change make this a significant topic for scientists, policy-makers and disaster management practitioners.

1.2 Research Objectives and Questions

This thesis is a study of environmental disaster management in the Great Lakes region. The purpose of this research is to investigate potential environmental disasters in the Great Lakes region; how they are currently managed by governments; identify and describe existing institutional arrangements, policies and management systems related to environmental disasters; and explore and assess the current state of environmental disaster management in the region. While recognizing that there are a range of actors and organizations from the non-government and private sector involved in environmental disaster management in the region, the scope of this study focuses on government arrangements at the transboundary, national, subnational scales related to environmental disasters.

This study seeks to explore the current state of environmental disaster management related to three central research questions:

- (1)** What government arrangements exist related to environmental disaster management in the Great Lakes region?
- (2)** To what extent are government arrangements functioning to manage environmental disasters in the region?
- (3)** To what extent are governments the Great Lakes region prepared for, or have the capacity to, manage environmental disasters?

1.3 Thesis Outline

This introduction provides the broad context and significance of environmental disasters and outlines the central research questions. Section 2 outlines the research methods, Section 3 reviews the interdisciplinary scholarly literature related to environmental disaster management and Section 4 presents the findings.

The next section, Section 2, details the research design and methods used to collect information related to the central research questions. As detailed in Section 2, this study used a three-stage research design involving: i) the collection and review of published secondary sources including books, journal articles, government reports, and strategic plans; ii) information and insights collected from being a participant in a regional expert forum on Great Lakes early warning systems; and iii) insights from key informant interviews with experts and stakeholders from federal government agencies in the region.

Section 3 provides a review of the interdisciplinary literature related to environmental disaster management generally and specifically related to the Great Lakes region. The third section of this thesis provides a literature review of the phases of disaster management, the history of environmental disasters in the Great Lakes region, and the existing governance and management structures and systems related to environmental disaster management in the region. It covers the existing knowledge and state of environmental disaster management in the Great Lakes region to date.

Section 4 presents the findings and analysis from the three phases of research and overall findings from the information and data collected. Finally, Section 5 outlines the conclusions, including some recommendations related to environmental disaster management in the Great Lakes region and avenues for future research.

2.0 Research Methods

2.1 Research Design and Data Collection Methods

This master's thesis aims to answer the research questions that are stated in Chapter 1 through a three-phased approach using a combination of qualitative research methods.

2.2 Collection and Review of Secondary Sources

The first method focused on the collection, review, and analysis of relevant academic literature and publicly available government documents concerning environmental disaster management in the Great Lakes. It began with the collection of all relevant scholarly and government publications that provided background information related to environmental governance broadly, and specifically related to the Great Lakes. This included collecting documents related to environmental disaster management at the binational, national/federal and state/provincial levels. The purpose of this first stage was to determine from secondary sources, which environmental disaster management knowledge, institutions and management systems exist related to research questions 1 and 2.

Several reports and government documents were reviewed to explore the current state of environmental disaster management in the Great Lakes. The majority of the documents were published online on the official websites of the International Joint Commission (IJC), Canada Public Safety (CPS), Environment Canada and Climate Change (ECCC), the United States Environmental Protection Agency (EPA), the US Federal Emergency Management Agency (FEMA) and other institutions. Wherever possible, scholarly sources and government documents related to policies and programs for environmental disaster management in the Great Lakes were collected. As an under-researched topic, there were few government documents found related to environmental disaster management in the Great Lakes. Those that were collected focused on emergency preparedness and response for specific types of environmental disasters such as oil

spills and hazardous material emergencies. Some documents and information were collected from an initiative that started at the same time as this research project, the International Joint Commission's (IJC's) Great Lakes Early Warning System (GLEWS) Working Group.

3.3 Great Lakes Early Warning System (GLEWS) Workshop

The second method used to collect information, documents and insights stemmed from attending and being a participant at the Great Lakes Early Warning System Working Group forum in May 2018. The IJC invited over 30 experts from various institutions for a two-day workshop in Windsor, Ontario (see Appendix D for list of GLEWS Workshop participants). This workshop is part of an ongoing project of the IJC's Science Advisory Board from 2017-2020 to explore and examine the feasibility of developing an early warning system for the Great Lakes. My supervisor is a member of the GLEWS working group and she was invited to the workshop. As she was unable to attend, she received permission for me to attend to learn and participate related to my research project.

I attended the GLEWS workshop as a participant with the permission of the IJC and on behalf of Dr. Carolyn Johns to collect some base line knowledge from experts and practitioners working on issues related to environmental disaster management and early warning systems. The material for the workshop, the discussions at the workshop, and the draft final report of this working group contributed to my findings and provided information and sources for Phase 3 of my research which focused on key informant interviews. The GLEWS workshop also provided some suggestions for important literature and documents for me to collect related to the central research questions. In addition, some of the key informants approached for interviewees were selected or recommended by participants at the GLEWS workshop.

2.4 Key Informant Interviews

The third phase of the research focused on data collection using open-ended, semi structured interviews with a small sample of key informants with knowledge and experience of environmental disasters. These individuals were from government organizations that are engaged in the management of the Great Lakes environmental issues and have mandates related to environmental disasters.

Key informant interviews were selected as an appropriate method as Phases 1 and 2 revealed that the number of experts, community of practice, and state of environmental disaster management in the Great Lakes region was in a development stage. A survey would not have yielded any useful results as there are a limited number of individuals working on the topic of environmental disasters at the transboundary scale in the region and the early stages of this research indicated that it was important to focus on qualitative, exploratory research. Key informant interviews were selected as an appropriate method to collect information related to the central research questions also given the limited scholarly and government publications available on environmental disaster management in the Great Lakes region that was revealed in Phase 1.

The interviews were conducted with those who are considered key informants in this research field in order to better explore and investigate the research questions. Phase 1 indicated there were some key individuals with knowledge related to the topic and central research questions. According to the scholarly literature, “key informants, as a result of their personal skills, or position within a society, are able to provide more information and a deeper insight into what is going on around them” (Marshall, 1996). The key informants for this study were selected based on their experience, knowledge and involvement related to environmental disasters management in the Great Lakes. Some were identified from the GLEWS workshop and others

were identified through publicly available documents and government agencies that are involved in the Great Lakes.

It should be noted that from the outset it was a challenge to identify and recruit key informants to participate in this study due to the lack of experts who focus specifically on environmental disaster management in the Great Lakes region. Based on the document review and the GLEWS workshop, a total of 50 officials were invited by email to participate in key informant interviews (see Appendix B for recruitment email). These 50 officials are from various government organizations in Canada and the United States including the International Joint Commission (IJC both US and Canada sections), Federal Emergency Management Agency (FEMA), Public Safety Canada (PSC), US Environmental Protection Agency (EPA), Environment and Climate Change Canada (ECCC), National Oceanic and Atmospheric Administration (NOAA), and other state agencies. Of the 50 invited, only 8 officials agreed to participate. A total of 33 officials declined to participate citing lack of knowledge and expertise; another 5 people did not reply at all; 3 declined to participate due to retirement or change of position; and 1 declined due to strict organizational policy to not participate in research interviews. From the original group of officials who agreed to participate, a snowball sampling technique was also used to increase the number of interviewees. Two out of the eight participants were recruited by using this technique.

Snowball sampling is a technique where interviewees are asked at the end of the interview if there is someone else the researcher should interview. Snowball sampling method is conducted in a situation where the study requires knowledge from subjects that are difficult to reach (Handcock and Gile, 2011). There are some limitations with this technique such as subject to human error and the fear of bias in referring to another candidate by participants, especially when taking into consideration the small number of participants in this study. However, best judgment was used to recruit officials with the knowledge and avoid candidates who have exactly the same views and perspectives.

This technique was used due to the small number of officials with the knowledge and expertise of environmental disaster management in the Great Lakes. During some of the interviews, interviewees recommend to interview specific officials that had already been interviewed. This reinforced that the population of officials with knowledge and expertise of environmental disaster management in the Great Lakes is small. Also, it indicates that because the number of government officials working on this topic is small, a significant number of experts in the field have been interviewed and participated in this study.

To collect information from key informants, a semi-structured interview method was used to allow participants to provide in-depth information and share their experiences without being restricted to specific choices and answers. According to Qu and Dumay, semi-structured interviews vary in comparison to full structured and unstructured interviews (2011). The semi-structured interviews consist of a list of planned questions, which are guided by pre-identified themes. These are mixed by general, unplanned questions that seek further details from the interviewees. This combination provides the interviewer with the flexibility to investigate deeply and dig more into the subject while remains on topic (Qu and Dumay, 2011). All interview participants were asked to provide their informed consent using a research ethics consent form approved by the Ryerson Research Ethics Board (see Appendix C). The semi-structured interview used an interview instrument consisting of 19 questions designed to collect information related to the three central research questions of this project (see Appendix A). Due to limited resources and time, all interviews were conducted online through Zoom software. With the consent of the participants, interviews were taped and transcribed.

The qualitative data from the key informant interviews was recorded and analyzed by using an unstructured content analysis method. Content analysis is defined as “a process for systematically categorizing messages in any type of communication including verbal, print, or electronic text data that are obtained from narrative responses, open-ended survey questions,

interviews, focus groups, observations, or print media including books and articles” (Kondracki et al., 2002). This process consists of coding and classification the data in order to generate themes of the significant findings (Kondracki et al., 2002). For this qualitative research, interviews were transcribed and analysis of the text was used to aggregate responses to the semi-structured interview questions and generate themes and important findings related to the central research questions. A coding book and framework was not used rather responses to each of the interview questions were aggregated and findings related to the central research questions were noted.

Overall, the three phases and various methods of data collection allowed for the collection of primary and secondary data to better investigate and understand to what government arrangements exist and are functioning, and to what extent is the Great Lakes region prepared and has the capacity to manage environmental disasters. This study also focuses on environmental disaster management specifically related to mitigation and preparedness. This is detailed in Section 3.2 below. In addition, an illustrative case study was used to explore existing binational, Canadian and United States arrangements related to environmental disaster management related to oil spills.

2.5 Illustrative Case

The research methodology used in this study also highlights that examining environmental disaster management in the Great Lakes region needs to examine what exists related to specific environmental disaster issues. Using an illustrative case allows for this. The GLEWS workshop indicated that there were some existing cases where transboundary, and Canadian and US arrangements existed related to specific environmental issues. Oil spills was a potential environmental disaster area where some work had been done.

The use of an illustrative case allowed for the integration of insights and findings from the other three phases of research. The case used for this purpose was one that was mentioned in the

GLEWS workshop and by some interviewees during key informant interviews: the Enbridge Line 5 that is located under the Straits of Mackinac Island in the US State of Michigan and viewed as having some potential to be a possible environmental disaster.

Overall, the research methods selected for this study related to the research questions focus on government-led arrangements and initiatives. The literature on environmental disaster management does highlight that that networks of government and non-government organizations and actors are critical in environmental disaster management but due to constraints of time and resources, the scope of this study focuses on government-led arrangements and initiatives, government actors in interviews (particularly national, state and provincial), and the role of government organizations and actors primarily in the illustrative case, rather than the full range of non-government and private sector organizations and actors who may be involved in environmental disaster management in the region.

2.6 Limitations and Considerations

There are several limitations and considerations that need to be outlined related to this research project. There is very little existing scholarship and literature on environmental disaster management in the Great Lakes region. As the literature reviewed in Section 3 outlines, there have been some very important environmental disasters in the region but they have primarily been viewed as local environmental disasters or within the confines of the jurisdiction of Canada and the US. Only recently has the transboundary policy community begun to explore the potential for transboundary threats, stressors and environmental disasters. This is an important limitation as environmental disasters have not been a major priority in the region and strategic transboundary arrangements have only very recently been considered an important frontier for strategic thinking, capacity building and action.

Second, the scope of this Master's thesis was limited to a focus on the research questions related to major government organizations in Canada and the United States that are in charge of governance of the Great Lakes. The literature reviewed in the next section clearly outlines that environmental disaster management involves local and network approaches that include both government and non-government organizations, actors and initiatives, particularly related to response and recovery. This research thus has limitations in terms of its scope. It is exploratory and descriptive. There are many research questions and frontiers of research related to environmental disaster management in the region. Some of these are outlined in the conclusion.

As noted above, there are also some limitations related to the snowball sampling technique and the limited number of interviews conducted for this study. The number of interviews is a small sample. However, this sample contains key informants who provided significant insights and contribution to the topic of this research. Some of the participants in this study are top officials in their organizations and well informed of environmental concerns and policies in the Great Lakes region.

Finally, there are important ethical considerations related to this thesis. In order to complete this thesis, Ryerson University requires that all research projects involving human subjects have to be submitted to the Ryerson Ethics Board (REB) for ethical review. Interview questions, recruitment text and a consent form were submitted with an application to REB for ethical review. The board approved the application on May 29th, 2018. All related REB documents are contained in the Appendices. The REB requires all participants' information remain confidential, which was assured by not using any direct attribution to interviewees or any identifying information in the reporting of findings. Data and transcribed notes were stored and secured and the investigator and his supervisor are the only people who have access to the data. The data will be destroyed one year after the thesis is completed as per Ryerson REB requirements.

3.0 Literature Review

As noted in the introduction, there is a vast and growing scholarship on disasters and disaster management. Within this literature, there is a significant literature on environmental disasters. The brief review in the introduction also highlights that there is a need for conceptual clarity as sometimes the concepts of natural disasters and environment disasters are used interchangeably. This stems from the fact that there is no one definition of disaster or disaster management. The literature focused on disasters and disaster management has grown considerably to the point that there are now a range of scholarly journals from different fields focused on disasters and disaster management including: *Journal of Natural Disasters*, *Environmental Disasters*, *Natural Hazards and Disaster Prevention and Management*.

This literature review section begins with some key definitions drawn from the literature; it includes a review of the phases of disaster management; followed by a review of the history of environmental disasters in the Great Lakes region.

3.1 Definitions of Disaster and Environmental Disaster

There are challenges with proposing a definition of disaster given that definitions vary depending on the audience, the area of study and its purpose (Rodríguez et al., 2006). The Halifax explosion dissertation by Samuel Prince is considered the first “systematic study” of disaster in 1920 (Rodríguez et al., 2006). In this work disaster was defined primarily as a human, man-made disaster. Several empirical studies have investigated disaster since the 1950s, all using different definitions related to various disasters. The numerous and different definitions of disaster in the literature stem from the fact that the field of disaster studies and management is an interdisciplinary field and there are numerous academic disciplines associated with it (Alexander, 1997). Thus, there is no universal definition of disaster in the literature that is used

worldwide (Shaluf et al., 2003). This causes a disagreement among scholars on the definition of disaster management and its theoretical components (Lettieri et al., 2009).

This thesis adopts the following definition of *disaster*: “a serious disruption of the functioning of society, causing widespread human, material or environmental losses which exceed the ability of affected society to cope using only its own resources” (Mohamed Shaluf, 2007). This thesis proposes and uses the following definition of *environmental disaster*: a catastrophic event having significant disruption on the environment due to natural or human activity. This definition is used because there is no suitable or sufficient definition in the scholarly and practitioner literature.

The definition used here is broader than some which focus only on environmental disasters that are caused by human activity or more narrow definitions that define environmental disasters as the sudden release of a catastrophic quantity of pollutants into the environment (Jenkins, 2000). The definition used here is intentionally broad in order to capture how environmental disasters are conceptualized in the Great Lakes region.

There are some existing definitions of disaster in the literature and within government organizations in the Great Lakes region. This study emphasizes on defining environmental disaster in the context of the Great lakes region and these definitions are not included in this study for the following reasons. The criteria to define disaster are problematic and do not serve the context of environmental disaster management in the Great Lakes region. For instance, Public Safety Canada defines disaster as, “A social phenomenon that results when a hazard intersects with a vulnerable community in a way that exceeds or overwhelms the community's ability to cope and may cause serious harm to the safety, health, welfare, property or environment of people; may be triggered by a naturally occurring phenomenon which has its origins within the geophysical or biological environment or by human action or error, whether malicious or unintentional, including technological failures, accidents and terrorist acts” (Government of

Canada, PSC Canada, 2018). In order for a disaster to be included in the Disaster Database of Public Safety Canada, it has to meet some criteria such as death of ten or more people and 100 people or more being injured and affected due to the disaster (Government of Canada, 2019). These human-centred criteria are problematic especially in the context of the Great Lakes region. If a disaster hits one of the Great Lakes and causes catastrophic impacts on the ecological system of the lake, this will not be categorized as a disaster according to these criteria. Thus, a specific definition of environmental disaster is critical in the context of the Great Lakes and to acknowledge that environmental disasters can have both human and ecological impacts in the region.

Some literature also refers to environmental disasters as ecological disasters or environmental hazards but it is important to distinguish the definition of environmental disaster from environmental hazard. In the literature, environmental hazard and environmental disaster do not mean the same thing (Paul, 2011). Environmental hazards trigger threats to people including deaths, disease and injury; to goods such as economic and property damages; and to the environment such as pollution and loss of plants and animals. It “refers to all the potential threats facing human society by events that originate in, and are transmitted through, the environment” (Smith and Petley, 2009). Environmental hazards can be defined as “extreme geophysical events, biological processes and technological accidents that release concentrations of energy or materials into the environment on a sufficiently large scale to pose major threats to human life and economic assets” (Smith and Petley, 2009).

The literature of hazards contains different classifications and groups of hazards and numerous researchers propose diverse categories. Paul in his textbook *Environmental Hazards and Disasters* summarizes the types of hazards into five major groups (2011, pp. 16-20). First, natural hazards arise from natural developments such as tsunamis, earthquakes, floods, volcanic eruptions, hurricanes, thunderstorms and tornados. Second, social hazards or intentional

hazards arise by human action within social systems such as acts of terrorism, warfare, famine and civil or armed conflicts. Third, biological hazards originate from sources such as viruses, plants, animals, birds, human, bacteria, medical wastes and insects, which result in infections, health catastrophes and deaths. Fourth, technological hazards are the result of the interaction of technology, natural systems and society. Examples of this category are oil spills, explosions and release of toxic substances. Finally, chronic hazards are not acute events that happen suddenly, they are a long term and arise from continuous conditions and issues. Examples of this group of hazards are ongoing pollution and resource degradation.

The definitions and relationships between hazards, disasters and risks can be confusing. Smith and Petley describe the differences using a clear illustration: hazard is the possible danger to people and their environment, which is considered as the cause; risk is the possible consequence, “the probability of hazard occurring and creating loss” (2009); and disaster is “the realization of hazard, the actual consequence” (Smith and Petley, 2009).

Disasters can be grouped in three main classifications or types: natural disasters, human-made disasters and hybrid disasters (Mohamed Shaluf, 2007). For purposes of this thesis, the focus is on environmental disasters that include these three types. Where necessary, the specific types are referred to.

In addition to using these definitions of disasters, and specifically environmental disasters, it is important to also define disaster management. Avoidance, reduction of human and economic losses, delivering appropriate assistance to victims of disasters, and speedy recovery are the typical objectives that disaster management experts seek to understand and achieve (Othman and Beydoun, 2013). For purposes of this thesis, disaster management is defined as managing the risks and consequences of a disaster, which requires planning and responses through all the phases of a disaster incident: mitigation, preparedness, response and recovery

(Othman and Beydoun, 2013). This definition is based on conceptualizing disaster management in phases.

3.1.2 Phases of Disaster Management

Different studies focus on different disasters and different stages, or phases, of disaster management. The literature generally conceptualizes disasters as part of a cycle consisting of 4 major phases: mitigation, preparedness, response and recovery as shown in figure 1 (Altay and Green, 2006; Noori and Weber, 2016).



Figure 1: Disaster Cycle

Numerous activities of planning and responses are associated with all the phases of disaster management (Othman and Beydoun, 2013). The activities of disaster management are complicated and not exactly straightforward before, during and after a disaster. Human responses can be reactive and proactive. The mitigation phase aims to reduce impacts on people

and property through actions taken before or after the hazard incident (Henstra and McBean, 2005). The preparedness phase contains various components such as early warning, training, planning and establishing needed emergency services in place. These are the 'before disaster' stages (Gasparini et al., 2007; Wex et al., 2014).

The response phase is part of the 'during and after disaster' stage. This phase consists of activities such as rescue missions, relief aids, emergency shelter and settlement and providing the needed assistance to the survivors or those negatively impacted by a disaster (Schryen et al., 2015). The recovery phase deals with tasks such as search for missing people, public infrastructure repair, recovery of major facilities and reconstruction of residential and business buildings, research and data analysis. This phase is considered the final and 'after disaster' or sometime is called the 'post-disaster' stage (Noori and Weber, 2016; Schryen et al., 2015; Wex et al., 2014).

All phases in the disaster cycle involve various levels of governments, non-government and private sector organizations at different phases (Othman and Beydoun, 2016). Scholars from different fields in the literature focus on different stages and the role of different sectors, organizations and actors. While recognizing that a governance approach is very valuable as it covers the wide range of state and non-state actors and organizations involved in environmental governance and the importance of all actors working together to address environmental problems in sustainable ways (Martin and Webb, 2020), governments remain at the core of emergency management governance arrangements and collaborative networks and exploring the role of governments in various phases of the disaster cycle and disaster management remains an important research focus. As noted in the introduction, this study focuses on the mitigation and preparedness stages of environmental disaster management in the Great Lakes region.

In Canada, all three levels of government share responsibility for disaster management. As detailed in Section 3.4.3 below, Canada Public Safety is the federal agency that facilitates and

coordinates numerous duties of disaster management within provincial and municipal organizations and other agencies. Most regional or local disasters are under provincial jurisdiction and provinces delegate authority to municipal governments in regard to disaster management policies and actions (Henstra and McBean, 2005). Most provinces have their own leading agencies of disaster management such as Emergency Management Ontario (Henstra and McBean, 2005).

In the United States, emergency management agencies at the local, state and federal levels are responsible for disaster management (Giuffrida, 1985). As detailed in Section 3.4.3 below, the Federal Emergency Management Agency (FEMA) is the federal leading agency for disasters and plays a fundamental role in all stages of disaster management, which are mitigation, preparedness, response and recovery (Giuffrida, 1985; Sadiq et al., 2016). In addition, federal agencies classify mitigation and preparedness in one category and response and recovery in another. Through the disaster cycle, each stage is important and consists of numerous activities to address a disaster. Recently, there is more emphasis given to the stage of mitigation and preparedness in comparison to other stages of the disaster cycle.

It is important to keep these stages in mind when reviewing some of the laws and governance arrangements in Canada, the United States, and the Great Lakes region related to environmental disaster management as these various stages are associated with different levels of government response and responsibility. As detailed in Sections 3.4 below, much of environmental disaster management to date has focused on response and much less on mitigation and preparedness. This is also important as there is an assumption that past environmental disasters have been local, with low probability, and focused on local and national response, rather than regional mitigation and preparedness. However, as the next section outlines, there is a history of environmental disasters in the region, and some increasing concern that some may become more likely and more regional in the future.

3.2 Definitions of Governance and Capacity

Before getting into the history of environmental disasters in the Great Lakes, it is important to define two concepts related to the central questions of this study: governance and capacity. First of all, there are various definitions of governance in the literature and there is not a full consensus about the definition of governance among scholars (Rodriquez & Rodriquez, 2019). For the purpose of this research, *governance* refers to “a set of decisions and processes made to reflect social expectations through the management or leadership of the government and by extension, under liberal democratic ideals, the will of ‘the people’ as they rule themselves” (Fasenfest, 2010). Thus, governance is distinct from government which refers to “the office, authority or function of governing” (Fasenfest, 2010). In other words, government focuses on state institutions, organizations and actors, where governance is a broader concept that focuses on a range of actors collectively involved in the process and practice of governing.

Secondly, there are various definitions and different types of capacity in the literature. Some of the definitions focus on physical capacity; others emphasize on the economic capacity of a society. For the purpose of this research, the following definition from the United Nation Office for Disaster Risk Reduction (UNDRR) is used to define capacity in the context of environmental disaster management: “Capacity is the combination of all the strengths, attributes and resources available within an organization, community or society to manage and reduce disaster risks and strengthen resilience” (UNDRR, 2020).

Finally, for purposes of this research study there is a need to define what is meant by capacity to manage environmental disasters in any given jurisdiction or region. The purpose of this study is to focus on policy capacity, the specific capacity that exists in the region to mitigate and have some level of preparedness related to environmental disaster management. The definition of capacity in this study therefore focuses on those specific phases of the disaster

management cycle that require some scientific, strategic, policy capacity on a regional scale related to potential environmental disasters in the region. As the next section outlines, historically, and with changes in the region, there is a need for some capacity to anticipate, mitigate, and be prepared to address potential environmental disasters. By addressing the central research questions, this study hopes to provide some evidence and assessment of current policy capacity related to environmental disaster management in the region.

3.3 History of Environmental Disasters in the Great Lakes

The Great Lakes-St. Lawrence River basin is the largest system of freshwater in the world; spread over 94,000 square miles (Bartolai et al., 2015; Clamen and Macfarlane, 2015). The region is home to the longest border between Canada and the United States, which consists of 8000 km; 40% of this border is water including streams and rivers, the five Great Lakes and 300 lakes and connecting channels in the basin (Grover and Krantzberg, 2015). The basin provides water for different uses such as drinking, industrial, agricultural, waste disposal, recreation, hydro-electricity, spiritual, and cultural uses (Bartolai et al., 2015; Johns, 2009). Given the vastness of this natural system, it is not surprising that the Great Lakes has experienced various environmental disasters in the past.

The Great Lakes region has a long history with environmental disasters (Kadar, 2011). In her book of *Disaster Great Lakes*, Megan Long has documented over 60 catastrophic events that hit the Great Lakes (Long, 2002). Her book traces the oldest documented environmental disaster in the Great Lakes region back to 1780, when the British royal navy lost a large ship as a result of a hurricane and caused 115 deaths (Long, 2002. pp. 32-35). Her book documents that from 1780 to 1979, 63 environmental disasters occurred in the Great Lakes region (Long, 2002), many weather-related and storms that caused shipwrecks.

These environmental disasters consist of different events that caused by natural and human-made hazards. Examples of the environmental disasters include Hurricane-force winds in Lake Ontario and Lake Erie in 1844 that caused 200 deaths; the Great flood of Erie Pennsylvania in 1915 that resulted in 26 deaths; the Cloquet-Moose Lake fire in 1918 that caused 800 deaths; the Armistice day storm in 1940 resulting in 70 deaths; and the Detroit Metropolitan water system tunnel explosion in Port Huron, Michigan in 1971 (Long, 2002). According to Long, the 63 environmental disasters of the Great Lakes region combined account for a total of 10,000 deaths (2002). Additionally, other well documented and significant environmental disasters occurred in the Great Lakes region including the White Hurricane 1913, Hurricane Hazel 1954, Flood of 2013 and the Great Spring Flood of 2017.

The White Hurricane hit the Great Lakes region on November 7, 1913 and lasted for four days (Potter, 2016; Kerfoot, 2015). The hurricane caused destruction unlike anything seen in the history of the region. This natural disaster is one of the deadliest events in the history of the Great Lakes and it led to the death of over 250 people (Kerfoot, 2015). Some 12 ships sunk, 31 grounded on beaches or rocks and many were severely damaged due to the hurricane. Furthermore, 8 boats with their entire crews were lost on Lake Huron alone (Potter, 2016; Kerfoot, 2015). These lost boats include Argus, Isaac M. Scott and Regina, which were lost in Lake Huron on November 9th (Potter, 2016). Despite some awareness that a storm was coming, shipping companies and sailors blamed the Weather Bureau for not adequately warning them about the severity of the hurricane. However, the Weather Bureau responded that shipping companies and sailors did not take their warnings seriously (Potter, 2016).

Hurricane Hazel is another major disaster in the history of the Great Lakes. On Friday October 16, 1954, Hurricane Hazel hit South-Central Ontario on its way passing to New York State through Lake Ontario with wind speeds up to 75 miles per hour, causing flash floods in the watersheds surrounding the City of Toronto (Gifford, 2004), resulting in severe damages to

infrastructure, and the evacuation of hundreds of families within the city (Robinson and Cruikshank, 2006). In Toronto alone, it killed 81 people and left more than 1,868 people homeless. It caused significant damage to the city's infrastructure, 20 bridges were destroyed and full blocks of homes were swept away, resulting in final damages estimated at the time to be close to one billion dollar (Gifford, 2004). In its aftermath, the province formed the Toronto and Region Conservation Authority to address flood vulnerability across all its watersheds.

In 2013, a major rain event hit the City of Toronto. Within three hours, two major thunderstorms passed over Toronto, dumping a record-breaking 126 mm in rainfall. Although very localized, the rainfall caused basement flooding, sewage overflows, stopping traffic and causing millions of dollars in damages (Satnford and Freek, 2014. pp. 77-82). These damages affected the city's water infrastructure and stormwater management system. The rainfall in one day was more than the total amount usually seen in a month. It was the largest rainfall on record since Hurricane Hazel in 1954 of 121 mm (Environment Canada, 2014). This natural disaster was followed by a major ice storm in December 2013 when almost 500,000 people across southern Ontario were left without power due to the storm.

The Great Spring Flood of 2017 was a massive environmental disaster, which triggered intense political reactions among authorities in the Great Lakes region (Wendel, 2017). The flood impacted parts of Ontario, Quebec and New York in April and May 2017. The estimated economic damage of the flood was more than \$223 million in Ontario and Quebec. Toronto Islands and beaches were submerged for most of the summer and the City of Toronto lost \$5 million in revenue due to the closure of Toronto Island as a result of the flood. More than 4,480 people were affected and 3,600 others were evacuated in Quebec and more than 1,650 federal government soldiers joined to help in Quebec. The US military joined to help in to cope with the disaster in New York (Wendel, 2017).

Natural disasters in the region are hard to predict and not regular occurrences. There was 41 years between the White Hurricane and Hurricane Hazel. Almost 60 years passed between these events and the major flooding disasters of 2013 and 2017. Some of these events have been more localized and others having impacts throughout the Great Lakes region. In many of these cases there has been very limited disaster management, related to any of the four phases outlined above. In order to fully assess existing approaches and governance arrangements related to environmental disaster management in the region it is therefore important to understand how environmental disaster management fits within existing governance arrangements in the region. A review of the governance regime at various scales is important to understand and assess the research questions related to environmental disaster management in the region.

3.4 Governance of the Great Lakes Region

The Great Lakes basin is shared between two federal governments, eight US states and two Canadian provinces (as shown in Figure 2) more than 120 First Nations and tribes and hundreds of regional and local government and non-government agencies (Johns, 2009). The Great Lakes region contributes significantly to both the Canadian and US economy. 56 million jobs for Canadians and Americans combined are connected to the Great Lakes region (Clamen & Macfarlane, 2015; Kavic, 2015). It has a population of 105 million people, including one-quarter of the population of Canada and one-tenth of the US population (Kavcic, 2015). In 2013, a survey among the residents of the Great Lakes showed that 71% of the Great Lakes residents think that the Great Lakes impact their daily life significantly, 54% stated that they ate at least a fish from one of the lakes in the last year, another 54% visited a beach in the Great Lakes, 98% had visited one of the lakes at least and 94% think that the Great Lakes is an important economic resource for their provinces and states (Maack et al., 2014).



Figure 2: Map of the Great Lakes Region (Sen Nag, 2018).

3.4.1 Binational Governance of the Great Lakes Region Related to Environmental Disasters

Understanding environmental disaster management in the Great Lakes region requires a multi-level analysis of the institutions and actors involved in environmental governance more broadly. While not all environmental disasters require basin-wide or binational responses, the region has an environmental governance regime that focuses on a range of environmental issues and there have been some recent efforts to develop some capacity to work on environmental disasters across the region and related to climate change. For purposes of this literature review, only the agreements and institutions with some relevance to environmental governance and environmental disasters are reviewed.

The binational governance of the Great lakes region can be viewed through the lens of two fundamental international agreements, which are the Boundary Waters Treaty (BWT) and the Great Lakes Water Quality Agreement (GLWQA). The history of binational governance of the Great Lakes region has evolved since the early years of the twentieth century with the innovation of the Boundary Waters Treaty that was signed in 1909 (IJC, 2016). During that time, the Boundary Waters Treaty was an extraordinary international agreement in terms of governing trans-boundary waters (Muldoon, 2012).

The BWT was originally established to address disputes and manage water quantity and quality issues along the United States and Canada boundary (IJC, 2016). It was a result of ongoing issues related to the management of water resources in the Great Lakes region such as navigational canals, hydropower and infrastructure projects (Botts and Muldoon, 2005). The Treaty consists of 14 articles and established the International Joint Commission (IJC) as a transboundary organization under Article VI (IJC, 2016).

The IJC plays a major role in transboundary governance and the history of the IJC is well-documented (MacFarlane and Clamen 2019). It was established historically as a binational organization to prevent and collaboratively manage conflicts between Canada and the United States (Botts and Muldoon, 2005). The IJC's responsibilities include investigating boundary and transboundary issues and monitoring activities of water levels and flows in the basin; and presenting scientific reports and recommendations to both governments (IJC, 2016). The IJC has powers to investigate transboundary issues, commission scientific research and studies through its Science Advisory Board (SAB) and Water Quality Board (WQB), and works to address issues and resolve conflicts through its various Boards across the Canada and US border, within and outside of the Great Lakes region.

The IJC consists of six commissioners; three are appointed by the Canadian federal government and Prime Minister and the three are appointed by the United States President (Jetoo, 2018). The IJC is an advisory body and it does not have any authority to act independently (Hall, 2006). However, it may act independently in one condition: where a joint delegation of power from the US and Canada is issued to do so in regard to specific conflicts and circumstances (Hall, 2006 & Palay, 2009).

In its early years the IJC managed issues related to water use, shipping, and diversions. As outlined in Figure 3, there are many diversions that affect water and the environment in the Great Lakes.

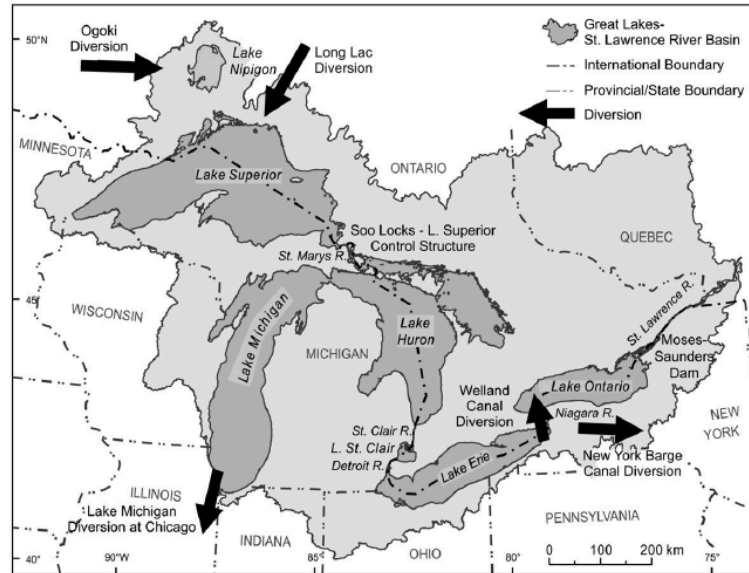


Figure 3: Map of the Great Lakes basin and its diversions (Maghrebi et al., 2015).

As environmental issues began to emerge in the region, the BWT became the foundation for collaborative action on a range of water quantity and water quality issues.

The other major component of binational governance related to environmental disasters is the Great Lakes Water Quality Agreement (GLWQA). It was signed between the US and Canadian Federal governments in accordance with the Boundary Water Treaty in 1972 (Government of Canada, 2013). The GLWQA is a consequence of the awareness of the water pollution issue in the basin among the public, scientists, and stakeholders which trigger binational negotiation between the two governments (Jetoo et al., 2015). The agreement aims to protect the Great Lakes and maintain the biological, chemical and physical integrity of the waters in the Great Lakes basin through restoration and cooperative effort by both governments (Government of Canada, 2013). Furthermore, it highlights the challenges that exist in the Great Lakes, some which require immediate actions. Massive phosphorous was a huge problem that led to significant growth in algae in the Great Lakes at that time (Botts and Muldoon, 2005). The issue was addressed after signing the agreement in 1972, which led to a major decline in phosphorous levels in the following years in the Great Lakes (Government of Canada, 2013).

The GLWQA was revised to include more management aspects of the ecosystem of the basin in 1978 (Hildebrand et al., 2002). This revision shifted the agreement from dealing with specific parts and issues in the basin to a broader approach of restoring the ecosystem as a whole regime to enhance the Great Lakes water quality (Hall & Houston, 2014). New initiatives and programs also emerged to tackle serious issues such as persistent toxic substances and industrial and municipal contaminants (Botts and Muldoon, 2005). In this revision, more stakeholders became involved; transparency and public engagement are included by publishing reports to reveal progress and achievements of the objectives (Jetoo et al., 2015; Vannijnatten and Johns 2019). Other public engagements and public reporting by the IJC are through the Triennial Assessment of Progress reports and the Great Lakes Public Forum that is held once every three years, various formal committees for each annex in the agreement and the Binational.net.

In 1987, the GLWQA was amended and the Great Lakes Water Quality Protocol introduced (Benidickson, 2016). The protocol contains more commitments and plans including Remedial Action Plans for Areas of Concerns and lake-wide management plans for protecting the Great Lakes (Government of Canada, 2013). Through this protocol, the US and Canadian federal governments issued this as an executive agreement, which does include a treaty status to create and implement cleaning up plans for 43 geographic locations that were highly polluted in the Great Lakes (Hildebrand et al., 2002).

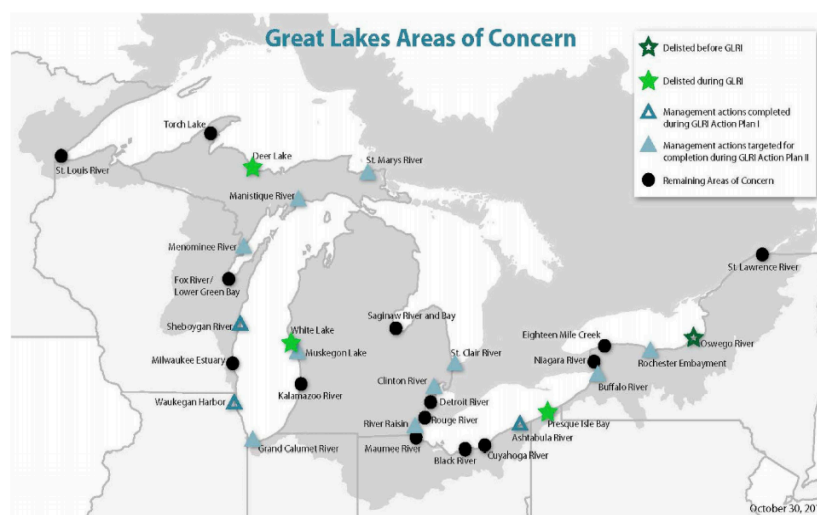


Figure 4: Areas of Concern of the Great Lakes (Holifield & Williams, 2019).

Since 1987 there has been a concerted focus on Areas of Concern (AOC) as shown in Figure 4, lake-wide management, and several environmental issues highlighted in some of the Annexes of the GLWQA (Government of Canada, 2013). Various binational programs have been developed due to the protocol such as the binational toxic strategy for persistent toxic substances and a binational conference to address the ecosystem's state of the Great Lakes (Hildebrand et al., 2002). Concerted binational efforts have been made over the past several decades to clean up and protect the lakes.

On the 7th of September 2012, the Great Lakes Water Quality Protocol was updated and signed by both federal governments (Government of Canada, 2017). The 2012 agreement is somewhat broader than the 1972 and 1987 agreements in terms of addressing more concerns and focusing on problems that are related to the governance of the Great Lakes (Jetoo et al., 2015). It consists of 10 significant Annexes:

Annex 1	Areas of Concern
Annex 2	Lakewide Management
Annex 3	Chemicals of Mutual Concern
Annex 4	Nutrients
Annex 5	Discharges from Vessels
Annex 6	Aquatic Invasive Species
Annex 7	Habitat and Species
Annex 8	Groundwater
Annex 9	Climate Change
Annex 10	Science

Most of the Annexes are designed to deal with current and on-going environmental issues in the region. The 2012 GLWQA agreement did develop new programs and implementation committees under the direction of the Great Lakes Executive Committee (GLEC) which is lead by ECCC and EPA, Annex co-leads from each federal government, and Annex committees with representatives and different stakeholders in the Great Lakes including state and provincial agencies, local public agencies and municipal governments, First Nations and tribal governments and other stakeholders critical for the purpose of achieving the objectives of the agreement (Jetoo et al., 2015)

There are some Annexes of the GLWQA that have scope related to environmental disaster management. For example, Annex 5, addresses the prevention and prohibition of oil spills on water in Section 1(a) (Binational.net, 2019). This annex also highlights the prevention of other hazardous spills in the Great Lakes. Annex 10, the Science Annex, also has some scope related to scientific capacity to anticipate and assess environmental threats. However, there is no specific Annex in the GLWQA related to environmental disaster management and no explicit focus on environmental disaster management in the region through GLEC. There is however some scope related to environmental disaster management through the IJC.

The IJC's two boards, the Water Quality Board (WQB), the Science Advisory Board (SAB) and the IJC also does have some scope related to environmental issues and potentially environmental disasters under the BWT related to its focus on water levels and through its focus on water quality through the GLWQA. In terms of IJC boards and water levels, this is primarily done through the International Lake Ontario-St. Lawrence River Board (ILO-SLRB), which regulates Lake Ontario outflows, ensuring they meet the requirements of the IJC's Order of Approval. The Board operates under the current regulation called Plan 2014 (IJC, 2019).

In terms of managing impacts of water levels, the IJC developed the Lake Ontario-St. Lawrence River Plan 2014 (IJC, 2016). This plan was developed to manage water levels and flows in Lake Ontario and the St. Lawrence River. It establishes certain criteria and specific conditions for water flow through the Moses-Saunders Dam, which is located between Cornwall, Ontario and Massena, New York (IJC, 2016). Additionally, the 2014 Plan provides benefits to various ecosystems by restoring plant diversity and habitat for fish and other organisms. It protects coastal development, municipal and industrial water use, recreational boating from extreme high or low water levels. The plan also maintains the same economic benefits for commercial navigation and generates slightly more hydropower with more natural fluctuations (IJC, 2016). It has some relevance related to flooding and water-level aspects of environmental disasters. However, Plan 2014 has received some criticisms related to its ability to manage floods and has not been used to explicitly focus on environmental disaster management.

Plan 2014 received criticisms after Lake Ontario increased almost a meter above its normal levels in April 2017, which caused a threat to residents and homes along the shorelines (Wendel, 2017). Politicians and residents on both sides of the border requested to increase the outflow from Lake Ontario into the St. Lawrence River because floods affected both sides and it was worse in New York. This request was made to the managers of the Moses-Saunders Dam, which regulates water levels in Lake Ontario. Yet, the IJC denied this request due to the reason that any increase in the outflow will result in more floods downstream along the St. Lawrence River (Wendel, 2017). Communities downstream along the St. Lawrence River to the north, to Montreal were flooded at the same time. Thus, if the IJC increased the outflow at that time, these communities would have been overwhelmed with more floods. As more rainfall occurred in May and June 2017, the situation became severe and more roads were closed on both sides of the border due to flood damages (Wendel, 2017).

Consequently, political tensions rose in the basin between regional authorities and the IJC.

During a speech in Wilson, New York, the Governor of New York, Andrew Cuomo, called on President Trump to fire the IJC officials (Wendel, 2017). Cuomo and other officials accused the new regulations for Lake Ontario in the 2014 Plan as the reason behind the massive flooding.

Lake Ontario water levels reached the highest level of record for the last 100 years in 2017 and these record water levels are thought to be linked to climate change and changes in temperature (IJC, 2017). Increasing frequency of floods may be an early sign of the impacts of climate change on the Great Lakes in the near future. However, the IJC has historical water level data that shows fluctuations in water levels as shown in figure 5. Therefore, Plan 2014 might not be to blame on the matter of the frequency of flooding in the Great Lakes.

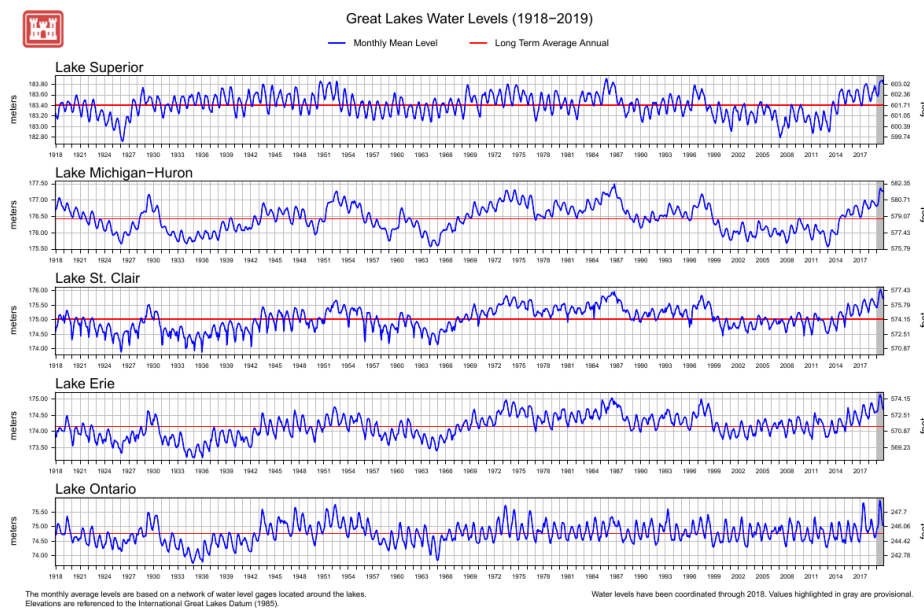


Figure 5: Fluctuations in Water Levels in the Great Lakes

Source: U.S. Army Corps of Engineers, *Great Lakes Water Levels 1918-2019*.

Floods and changes in water levels are not the only environmental hazards that scientists and policy-makers are concerned about. In the context of climate change reports and discussions, a series of other environmental disasters have been emerging as issues of concern, both natural and man-made.

As there is no explicit set of policies or governance arrangements related to potential threats, stressors, risks, or environmental disasters, in 2018, the International Joint Commission (IJC) established an interdisciplinary working group to discuss potential and emerging environmental stressors and threats in the Great Lakes, under the Science Advisory Board. In 2017 the Great Lakes Early System Working Group (GLEWS) was established.

3.4.2 The IJC's Great Lakes Early Warning System Working Group

In 2017, the IJC's Great Lakes Regional Office launched a project to address various environmental challenges that face the Great Lakes. This project was launched under the IJC's Great Lakes Science Advisory Board to address the need for an early warning system for the Great Lakes-St. Lawrence River System (Bunch, 2017). As a result, a group of experts was formed to address this concern, which is called the Great Lakes Early Warning System (GLEWS). "The working group will review and consolidate current knowledge and approaches of environmental early warning systems and evaluate their applicability to the Great Lakes, develop a conceptual framework for a Great Lakes early warning system, and organize an experts workshop to generate a list of current and potential Great Lakes stressors and threats including their extent, likelihood and severity, and identify potential management process to address them" (Bunch, 2017).

The primary motivation in developing GLEWS can be found in Article 5, Section 2(c) of the 2012 Great Lakes Water Quality Agreement, which states that, the IJC is directed to identify potential and emerging threats in the Great Lakes and develop an approach to tackle them (Binational.net, 2012). Therefore, the objectives of GLEWS was to identify emerging and potential stressors and threats and develop an early warning system framework for them. In May 2018, a workshop of experts for GLEWS was held by the IJC in Windsor, Ontario to meet these two objectives (Donahue and Slawewski, 2018). Over 30 members attended the workshop from various

educational institutions and organizations in Canada and the United States (See Appendix D). The findings from GLEWS are detailed in Section 4.

Overall, the binational environmental governance regime has developed and matured but does not currently have a specific agreement or mandate related to environmental disaster management. Environmental disaster management is not currently part of the binational governance arrangements and the literature reviewed indicates it is currently thought of as being the sole responsibility of each nation separately, rather than a regional and transboundary issue. In order to understand and analyze environmental disaster management in the region, it is therefore important to also outline the institutions and roles of the national, subnational and local levels of government related to environmental disaster management and keep in mind the supporting role of the non-government and private sector organizations, particularly in response and recovery efforts.

3.4.3 National Governance of the Great Lakes Region Related to Environmental Disaster Management

In Canada, the *Emergency Management Act* (2007) identifies roles and responsibilities, which stakeholders should perform within the emergency management system of Canada. It specifies the responsibility and leadership of Public Safety Canada, especially its Minister, which consists of coordinating various emergency management actions among government organizations, provinces and other actors (Government of Canada, 2019). The Act contains various sections including minister's responsibilities, orders or regulations and different amendments (Government of Canada, 2020). Public Safety Canada is the coordinator of disaster management at the national level among various federal departments related to emergencies. These departments include Environment and Climate Change Canada, Canadian Coast Guard, Health Canada, Transport Canada, Canadian Air Transport Security Authority, National Defense

and other agencies. The involvement of a specific agency depends on the type of the environmental disaster (Government of Canada, 2019).

Under the *Emergency Management Act*, Public Safety Canada plays a significant leadership role in managing and coordinating emergency and disaster management activities among provinces, entities and other government agencies (Russell, 2009, pp. 15-16). This responsibility consists of various tasks including identifying disasters, preparing emergency management plans, testing and implementing these plans (Russell, 2009). Public Safety Canada has 13 regional offices across the country including a regional office in Ontario and one in Quebec related to the Great Lakes-St. Lawrence Region. “The regional offices are the primary point of contact for the Department at the regional level. They provide support to departmental policy, program and operational areas across the organization, delivering core programs at the regional level, providing regional input and perspective, and supporting the coordination of federal responses to emergency events” (Government of Canada, 2016).

In Canada, there is currently a hierarchical approach to emergency and disaster management. The responsibility for disaster and emergency management begins at the individual level and if the disaster exceeds the capacity of the community level, the responsibility to respond goes to the local first responders. If the emergency exceeds the capacity of the local first responders level, the responsibility goes to the municipal governments to respond. If the capacity exceeds the responsibility of the municipal governments, then the responsibility goes to the provincial and territorial governments to respond. Provinces and territories can request assistance from the federal government if the disaster goes beyond their capacity to act (Russell, 2009, p. 22). In addition to this hierarchical approach to emergency and disaster management, there are a wide range of non-government and private sector organizations and actors involved. This is particularly the case related to response and recovery. However, for mitigation and planning, higher orders of government play a strategic policy and planning role.

In the United States, it is a somewhat similar scale where disaster management goes from bottom to top, from local governments to states, then they request assistance from the federal government if it exceeds the state capacity. In the United States, the Federal Emergency Management Agency (FEMA) is the federal lead agency on environmental disasters in the United States under *Robert T. Stafford Act*. “Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 100-707, signed into law November 23, 1988; amended the Disaster Relief Act of 1974, Public Law 93-288. It created the system in place today by which a presidential disaster declaration of an emergency triggers financial and physical assistance through FEMA. The Act gives FEMA the responsibility for coordinating government-wide relief efforts” (FEMA, 2019).

However, under the National Contingency Plan, the US Environmental Protection Agency EPA is the lead federal emergency organization within inland areas, which is responsible for disasters related to oil spills and other releases of hazardous substances. EPA also plays a major role to support during different environmental disasters (Lindsay, 2012). Furthermore, it is important to highlight two major plans between Canada and the United States, which are The Canada-United States Inland Pollution Contingency Plan and the Canada-United States Marine Pollution Contingency Plan.

The Canada-United States Marine Pollution Contingency Plan is a federal response agreement between Canadian Coast Guard and the US Coast Guards for responding to spills events that occur in the coastal waters and the Great Lakes region between the two countries (Government of Canada, 2020). This plan came in force internationally in 2017. It applies to all regions shared between Canada and the United States, including the Great Lakes region. The purpose of the Canada-United States Inland Pollution Contingency “is to facilitate a coordinated and integrated federal response to a polluting incident along the inland boundary and to provide a mechanism for cooperative responses among all levels of government” (US EPA, 2009). It is the responsibility of Environment and Climate Change Canada and the US Environmental Protection

Agency to implement this plan. Although both these binational plans apply in the Great Lakes region, these two plans do not address environmental disaster management in general and specifically environmental disaster management in the Great Lakes region.

3.4.4 Sub-National Governance of the Great Lakes Region Related to Environmental Disaster Management

In addition to the federal governments in each country, states and provinces play an important role in disaster management generally and environmental disaster management more specifically. In terms of environmental governance, the history of the sub-national involvement in water and environmental governance varies for water quantity and quality (Johns and Thorn 2015). Related to water quantity management, a subnational regime was developed between the US states, Ontario and Quebec with the establishment of the Great Lakes Basin Compact in 1968 (Botts and Muldoon, 2005). The compact is the result of a negotiation process between the eight US states, which are Indiana, Illinois, Minnesota, New York, Wisconsin, Michigan, Pennsylvania and Ohio with the input of the two Canadian provinces, Ontario and Quebec (IJC, 2013). Under this compact, the Great Lakes Commission (GLC) was established to investigate various concerns regarding water quantity and quality in the basin and make recommendations to the parties to take actions (IJC, 2013). The GLC and Compact do not currently have any content or provisions related to environmental disaster management and the compact has received some criticisms for not protecting or addressing environmental issues and ecosystem dimensions of the Great Lakes (Hall, 2006; Palay, 2009). This is because the water quality and quantity governance regimes have evolved differently at the subnational levels and in terms of intergovernmental relations (Johns and Thorn, 2015).

The water quantity regime has evolved over the years into a mature transboundary governance regime. In 1985, the eight US states of Indiana, Illinois, Minnesota, New York,

Wisconsin, Michigan, Pennsylvania and Ohio with the participation of Ontario and Québec created the Great lakes Charter due to the ongoing concern of water shortages and drought in North America at that time, which increased the fear of water diversions and water export in the Great Lakes (Palay, 2009). The Charter is a cooperative agreement between the parties to be committed to generate a database of all large consumptive uses and to the regulation of any new water consumption and large diversions (Hall, 2006). Managing water diversions and consumption in the Great Lakes basin are the two major objectives of the charter to address (Palay, 2009). However, the Charter has received criticisms and considered as a failure due to the fact that the charter did not include a legal mechanism for implementation, which make it hard to enforce in the Great Lakes (Camacho, 2008; Palay, 2009). It also does not have any provisions related to subnational governance of environmental disasters.

In terms of water quality, the GLC plays a supporting role and the states and provinces both play an important role related to implementing the GLWQA. In Canada, there is a formal Canada-Ontario agreement that is signed every five years between the Federal and Ontario governments. Currently, this intergovernmental agreement related to binational governance under the GLWQA does not include any specific content or text related to environmental disasters or environmental disaster management.

In Canada, every province and territory has an Emergency Management Act. Under this act, emergency authority and duties are outlined and emergency management organizations are established to manage disaster and emergency within the territory or province (Russell, 2009). In the United States, “emergency and disaster management systems begin as a local government function, with state and federal assistance responsibilities coming into play as the scale of an extreme hazard event increases. It can be characterized in terms of a bottom-up capacity” (Gerber, 2007). Every State has its own Emergency Management Act that indicates emergency management regulations and programs. To illustrate, the State of Michigan has its own Act that is

called Michigan Emergency Management Act of 1976. It states that it is “An Act to provide for planning, mitigation, response, and recovery from natural and human-made disaster within and outside this state; to create the Michigan emergency management advisory council and prescribe its powers and duties; to prescribe the powers and duties of certain state and local agencies and officials; to prescribe immunities and liabilities; to provide for the acceptance of gifts; and to repeal acts and parts of acts” (State of Michigan, 2020).

3.4.5 Role of Municipalities Related to Environmental Disaster Management

In Canada, under the Emergency Management Act of provinces and territories, the role of municipalities and local authorities are outlined in regard to emergency management. For instance, the province of Ontario has its own Act that is called *Emergency Management and Civil Protection Act of 2006*. This Act contains several sections including different responsibilities. It states that every municipality in Ontario is required to develop and implement an emergency management program (Government of Ontario, 2020). Furthermore, municipal emergency management organizations and plans are established as a result of this act in each province and territory (Russell, 2009). In the United States, local municipal governments are responsible for all stages of disaster regardless of the disaster type and how large or small the municipality is. Federal and state governments act as supporters during and after the disaster (Gerber, 2007).

These important laws at the national, subnational and local levels form the backbone of emergency management governance regimes in Canada and the US. In addition to the Boundary Waters Treaty and the GLWQA, they form the legal foundations for the government regime that exists to address environmental disasters that may occur in the Great Lakes region. While it is important to recognize that many other non-government and private sector actors are significant in the overall governance regime related to environmental disaster management, this thesis only focuses on the formal government regimes that exist related to environmental disaster management in the Great Lakes region.

3.5 Disaster Management Models and Principles from the Literature Review

There are numerous models for disaster management in the literature from various disciplines and fields. Many scholars and researchers propose different models and principles to deal with different types, aspects and stages of disasters. However, this section will review some conceptual models and principles for disaster management, particularly those that are relevant for environmental disaster management.

According to Kelly, there are various benefits of a disaster model, which include simplifying difficult incidents through the differentiation among urgent situations with a restricted period of time, it helps with quantifying numerous disaster incidents and provides a common understanding and ground for everyone who is participating in the disaster event (1998). Quarantelli proposed ten criteria for good disaster management (1997). These criteria serve as general principles and guidelines for an efficient approach to manage disasters according to him. For instance, “Mobilize resources and personals effectively” is one of the criterions that he suggested (Quarantelli, 1997). Mileti also proposed general principles and standards to manage the destructive influences of natural disasters (1999). However, the set of these principles are focused considerably on the prevention and reduction phases of disaster management. (Mileti, 1999).

Cyganik developed a model for disaster management, which consists of the four phases in the disaster cycle (2003). This model was based on the case of Virginia Hospital Centre post to the attacks of Sep. 11, 2001 (Cyganik, 2003). McEntire et al. developed an integrated approach to model how vulnerable a community to a disaster taking into consideration resiliency, which is the foundation of the organizational schools in natural hazards (2010). Additionally, Asghar et al., proposed a conceptual comprehensive model for disaster management after reviewing several disaster models (2006).

This comprehensive model, consists of the four components of the disaster cycle outlined in Figure 1, and includes key activities, which are associated with each stage. It also includes important strategic and risk management components. The Great Lakes region does not have a similar model for environmental disaster management such as this model. Research in the early phases of this study indicate that the region could have a similar model developed for environmental disasters in the Great Lakes. As outlined above, a significant activity of the preparedness stage is an early warning system, which GLEWS has been working on. This comprehensive model could be adapted for environmental disaster management in the Great Lakes to help advance a focus on the environmental impacts of disasters and help government organizations build policy capacity related to mitigation and preparedness for environmental disasters in the region.

3.6 Summary

Findings from the literature review section reveal that the definitions of disaster and disaster management are significant, yet challenging as there is no agreed upon definition of environmental disaster and environmental disaster management in the literature, nor in the Great Lakes region. This is due to the fact that disaster studies and management is an interdisciplinary field and there are numerous academic disciplines associated with it. A definition of environmental disaster does not exist in the Great Lakes region. It also reveals that through the disaster cycle, each stage is important and consists of numerous activities to address a disaster. Recently, there has been more emphasis given to the stage of mitigation and preparedness in comparison to the rest of the disaster cycle as emergency response and recovery plans have been developed at the local and subnational scales in the past two decades. Additionally, reviewing the history of environmental disasters in the Great Lakes is important

and it shows that the region has experienced major environmental disasters in the past such as Hurricane Hazel and recent flooding across the region. Thus, the region is not immune to environmental disasters and it should be prepared to respond in the future.

Numerous government arrangements exist related to environmental disaster management in the Great Lakes region including policies, laws and institutions. The BWT of 1909 and the GLWQA of 2012 are the main two international agreements at the binational level. The IJC's Great Lakes Early Warning System Working Group GLEWS of 2017 is a significant transboundary and expert-led initiative that has relevance for environmental disaster management in region. On the national level, both national governments have existing emergency management legislation and important lead agencies: FEMA, US EPA, NOAA, Public Safety Canada and ECCC are major government organizations that have different responsibilities for environmental disaster management in the Great Lakes region. States, provinces and municipalities also have developed response and recovery regimes. However, there is a gap related to mitigation and preparedness at the transboundary and regional scale. At the same time, the literature on environmental disaster management has developed in the past decade and jurisdictions around the world are trying to develop more policy capacity related to mitigation and preparedness, particularly related to climate change. There is a mature binational governance regime related to water quantity and quality management, and some developing capacity related to threats, stressors and early warning system frameworks, but no existing definitions or models related to environmental disaster management in the Great Lakes region. The next section presents findings from the review of secondary sources, GLEWS workshop, and key informant interviews related to the three central research questions.

4.0 Findings, Analysis and Discussion

4.1 Findings from Secondary Sources

Numerous secondary reports and government documents were reviewed in relation to environmental disaster management in the Great Lakes region. In fact, there is a significant shortage in documents that are specifically addressing environmental disasters whether natural or human made disasters. It is quite rare to see reports or government documents that discuss the matter of environmental disasters in them. The fundamental document on the Great Lakes region, which is the Great Lakes Quality Agreement, does not address the various types of environmental disasters. There is no specific Annex for environmental disasters within the agreement. The only part the agreement addresses is related to oil spills and other hazardous spills under Annex 5 of the GLQWA. It does not address the different kinds of environmental disasters that are discussed in Section 2 above.

There is no specific definition of environmental disaster within the different reports and documents that deal with environmental issues in the Great Lakes. The definition of environmental disaster in the context of the Great Lakes does not exist. Also, specific environmental disaster management systems or models are not discussed or mentioned within the various documents and reports.

It is quite challenging to explore what exists in terms of arrangements related to environmental disaster management in the Great Lakes without asking experts from the major agencies that are involved in the Great Lakes. It is difficult to determine to what extent is the region prepared or have the capacity to manage environmental disasters without the input of officials and experts who are working on environmental issues and concerns in the Great Lakes. Therefore, phase 2 and phase 3 were very important related to answering the main research questions in the introduction.

4.2 Findings from IJC's Great Lakes Early Warning System (GLEWS) Workshop

The researcher attended the Great Lakes Early Warning System GLEWS Experts workshop as a participant on behalf of Dr. Carolyn Johns held at the Holiday Inn in Windsor, Ontario May 14-15, 2018. The purpose of the workshop was to bring together thought leaders to identify emerging environmental stressors and threats to the ecosystem of the Great Lakes and develop a framework for an Early Warning System to protect the Great Lakes by identifying emerging and anticipated issues in the basin. The International Joint Commission hosted this workshop. Over 30 experts attended the workshop, which some were scientists, engineers and professors from various Canadian and American institutions (See Appendix D).

On the first day, it began with an introduction about the project. Then, experts were asked to generate a list of threats and stressors and prioritize them through facilitated small groups and discussions. They were also asked to identify elements of the early warning system that is suitable for the Great Lakes region. Also, they were asked to develop or suggest a conceptual framework for a Great Lakes Early Warning System to prepare and respond to these stressors and threats.

Participants at the workshop generated a list of threats and stressors including chemical threats and stressors such as oil spills from ships and pipelines; chemical pollutants such as phosphorous and organochlorine contaminants. Biological threats and stressors including invasive species and aquatic diseases were also identified. In addition, climate change received significant attention in the discussion due to its threats and stressors such as lake warming, low precipitation and increased frequency of flooding events. Nutrient threats and stressors include cyanobacteria blooms and phosphorous and nitrogen loading. Finally, human-made threats and stressors including eco-terrorism, power outages and other threats to water quality and quantity were tabled and discussed.

Participants were divided into four groups and asked to identify emerging and anticipated threats and stressors. Each group came up with roughly 10 threats and stressors and some of the stressors and threats are listed in Table 1. This was followed by a discussion among experts in regard to these stressors and threats.

1. Nutrients	9. Population growth	17. Economic drivers
2. Climate Change	10. Chemical toxicity	18. Groundwater
3. Land use change	11. Pollution	19. Hydrology
4. Habitat loss, degradation	12. Harmful algal blooms	20. Unsustainable practices
5. Short-term thinking	13. Microplastic	21. Lack of resources
6. Airborne	14. Water diversion	22. Policy changes
7. Terrorism	15. Temperature changes	23. Apathy
8. Aquatic invasive species	16. Plastics	24. Emerging diseases

Table 1: List of Threats and Stressors (not in order).

The second day of the workshop began with presentations from various guest speakers in regard to various related issues in the basin, challenges and applications of Early Warning Systems in other jurisdictions and issue areas. Then, participants were divided into the same groups and provided with six alternative frameworks for the possible structure of a GLEWS effort moving forward. Each group was asked to choose one preferred alternative related to next steps and possibility advancing a Great Lakes early warning system and explain the rationale behind their choice. The six alternatives were:

1. GLEWS Subcommittee under the International Joint Commission
2. Formal GLEWS with dedicated IJC Staff Support
3. Periodic GLEWS Conference
4. Assignment to Another Existing Entity
5. Status Quo
6. A New Independent Organization

The majority preferred alternative 1 and some experts preferred alternative 4. A discussion followed in regard to the pros and cons of each of the alternative frameworks.

The rest of the discussion in the forum focused on developing a framework for the Great Lakes Early Warning System and alternatives. An early warning system consists of three parts, which are foresight, indicators to identify threats and characteristics. Additionally, participants highlighted that various stakeholders in the region should be involved in designing GLEWS and the IJC should build upon other projects and early warning systems that existed already. In fact, there are 6 alternative frameworks for GLEWS were provided to participants at the workshop to discuss their advantages and disadvantages. These alternatives are Status Quo, GLEWS Committee under the IJC, GLEWS Conference, assign GLEWS to an existing entity, and establish a new independent organization and a formal GLEWS with dedicated IJC staff support.

Some experts at the GLEWS workshop were very focused on the impacts of environmental threats and stressors in the Great Lakes related to climate change, economic and population growth. In the following section, Findings from Key Informant Interviews, these three were also mentioned by the majority of respondents as factors that may be leading to an increasing number or intensity of environmental disasters in the region. Therefore, this finding from the workshop matches with the finding from the key informant interview. There was consensus among the workshop participants that climate change; population change and economic growth will play a role in the increase and intensity of environmental disasters in the Great Lakes region.

Overall, the GLEWS workshop focused more on environmental stressors and threats, especially the ones that will affect the ecological integrity of the Great Lakes. It did not focus explicitly on environmental disasters and experts did not discuss various types of environmental disasters including natural or human-made disasters, aside from oil spills.

There are a couple of lessons to take away from the GLEWS workshop that are important to highlight. First, there were various experts from different backgrounds and academic

institutions at the workshop. However, the majority of the members who attended the workshop and provided insights came from science and academic backgrounds. There were many ecologists, environmental scientists and a few engineers. This is not surprising given that the workshop was organized by the IJC's Science Advisory Board. It was also evident that very few were focused on disaster management or environmental disasters. In addition, there were very few social scientists at the workshop including sociologists, demographers, economists, public health experts, policy researchers and lawyers. Since environmental disasters are both a natural and social phenomenon, social scientists have a major role to play in a discussion like the GLEWS workshop, particularly related to policy and governance capacity.

Additionally, environmental disasters were not discussed at the workshop as significant threats and stressors in the Great Lakes. The implications of environmental disasters were not viewed as a strategic environmental concern in the region. This shows that officials and experts were focused on ecological threats and stressors but not potential environmental disasters in the region. The focus was on ecological threats and stressors related to the GLWQA and not more broadly related to potential human and natural disasters.

It was clear that there is some interest in the need to shift to a focus on mitigation and preparedness instead of the current reactive approach, which focuses more on the responding and recovery stages of the disaster cycle in Figure 1. As noted above, mitigation and preparedness stages require a proactive approach towards environmental disasters to build policy capacity to take actions ahead of time such as implementing strategic thinking, scenario planning, and thinking through related policies and programs of disaster mitigation and preparedness in the Great Lakes. In general, it is extremely helpful to start thinking today about different scenarios of what could happen if the Great Lakes experience various environmental disasters in the upcoming years taking into consideration the significant factors of climate change and population growth. Although some of this thinking and work is done within each country in

the region, the workshop indicated there is a need for some binational and transboundary work and some consideration of environmental disasters as part of a broader definition of stressors and threats.

Moreover, there was a lot of concentration on chronic environmental stressors and threats related to chemical and biological issues such as pollution in the GLEWS workshop. These stressors and threats are important to address and deal with, particularly related to water quality and the GLWQA, however, acute threats such as an environmental disaster are extremely critical to think about and address. The impacts of a single environmental disaster such as a hurricane or flood are potentially more significant than some of the environmental stressors, which were discussed by the experts from GLEWS. While ecological threats and stressors are important and critical parts of an early warning system, so are potential environmental disasters that may have regional effects. It was not clear from the workshop if the early warning system framework, would evolve to include environmental disasters.

In addition to a clear definition of stressors and threats, some classification using a risk management approach to indicate low, medium and high probability associated with different stressors and threats might help advance a framework that included environmental disasters. Definitions would help with the classification of various threats that face the region and clearly outlining what qualifies as an environmental disaster and various roles related to various stages of disaster management. The literature on environmental disaster management reviewed in Section 3 indicates that clear definitions and classifications assist with identifying and measuring the risks associated with different environmental threats, stressors and disasters. Thus, definitions are critical to developing a comprehensive environmental disaster management framework, one that could include ecological threats and stressors and various levels of risk.

Overall, environmental disasters were not considered as a major problem in the Great Lakes by GLEWS. The workshop indicated environmental disasters are not viewed as significant

threats in comparison to other issues such as plastic and nutrients. Some of the workshop's findings are connected with findings from the key informant interviews but slightly different in terms of contexts and identified issues as the key informants interviewed were asked explicit questions about environmental disaster management in the region.

4.3 Findings from Key Informant Interviews

A total of 50 experts were invited to participate in key informant interviews related to the central research questions in this study in 2018 and 2019. While this may appear as a limited sample, there are not a large number of practitioners and experts working at the interface of environmental management and disaster management. A total of 8 government officials agreed to participate in an interview. Although the number of participants who agreed to an interview is small, the eight officials who did participate did have different responsibilities related to environmental management and disaster management and were key individuals in their organizations with knowledge related to environmental disaster management from a regional, binational perspective. Some were leading officials in their organizations related to this research project and well-positioned to answer questions related to the three central research questions of this theses.

All eight participants were working in major agencies that are responsible for protecting the Great Lake with responsibilities for environmental management and/or disaster management. Three participants are American and the other five are Canadians. One of the participants is the director of the environmental emergencies unit in one of those federal organizations. Another participant is the director of his federal organization in one of the provinces/states. Two participants are currently scientists and senior environmental advisors in their organizations. One is a senior environmental advisor in his agency. Another participant is a senior environmental coordinator for his organization for the Great Lakes. One is a senior

scientific coordinator for response of his organization in the Great Lakes. He describes his role, as “We are little like consultants, although we are federal government, we come in and help the US coast guards with marine emergencies and they can be all kinds, but mostly oil and chemical spills. We are their science officers” (Interview with an American official, February 24, 2019). The last participant is a Canadian ecologist and the director of his federal agency that is working in the Great Lakes region.

Each interview began with asking participants their background and current roles including their experience related to environmental disasters in the Great Lakes region. The following sections present the findings related to the questions asked to each interviewee. The full list of interview questions is available in Appendix A.

Participants have different experiences in the environmental disaster management, where some officials have direct involvement with environmental disasters and others have indirect engagement. One participant has direct experience and he has been involved in about 30 chemical and oil spill events. Four participants had more limited experiences. However, they have indirect experiences on advising governments and other stakeholders on environmental issues related to disasters and various environmental threats in the Great Lakes. They have worked on environmental and risk assessments related to different environmental disasters. Also, they have participated in publishing reports and documents in regards to various environmental disasters and issues. One participant is in charge of preparing and responding to environmental emergencies in the Great Lakes. Two participants have direct experience as being directors of agencies that are responsible for policies and environmental emergencies response in the Great Lakes. The last participant’s experience is in training and developing plans for chemical and oil spills as he stated that “A lot of planning and a lot of training in the Great Lakes, practically in the Mackinac Straits” (Interview with an American official, February 24, 2019).

4.3.1 The Significance of Environmental Disasters in the Great Lakes

Participants were asked about how significant environmental disasters are in the Great Lakes region. Two respondents think that environmental disasters are not significant in the Great Lakes region and six expressed that environmental disasters are important and potentially significant.

One of the respondents who felt environmental disasters were not significant in the region remarked:

“Considering the totality of potential or real environmental stressors and threats that exist in the basin, I personally do not consider environmental disaster to be right near the top of the list. I think we have been very lucky here in the Great Lakes, unlike other aquatic systems, where they have experienced very serious environmental disasters that have had long lasting impacts on those systems” (Interview with a Canadian official, July 12, 2018).

According to another respondent, environmental disasters are not significant because there are very few large environmental emergencies in the Great Lakes and there are systems and Acts in place to prevent and respond to spills from hazardous substances and recover damaged facilities (Interview with a Canadian official, May 14, 2019).

However, the other six respondents think that environmental disasters are very significant in the Great Lakes region. They all agree that environmental disasters are significant because Canada and the US rely so much on the Great Lakes water for different uses especially drinking water. One respondent stated: “Environmental disasters can be can be catastrophic in the Great Lakes. It is a very real concern that we have to address as countries. In terms of our institutions and agencies, to appreciate that risk curve is changing over time as a result of climate change, demographic, distribution of people across the basin” (Interview with a Canadian official,

July 11, 2018). According to another respondent, it can result in significant consequences to the economy; environment, people and species depending on the scale and magnitude of the environmental disaster (Interview with a Canadian official author, June 26, 2018).

Overall, key informant interviewees felt environmental disasters are very significant in the Great Lakes region due to the following reasons. First, the Great Lakes is a precarious environmental region that is significant not only to Canada and the United States but also to the whole world. It is the largest single drinking water source in the world. Thus, if a hurricane, earthquake, nuclear explosion or other types of environmental disasters occur in the region, there will be a massive impact on the environment in both countries. Second, it is significant because the Great Lakes is a crucial economic region for both Canada and the United States. It provides millions of jobs for both countries and a million barrels of crude oil are being transported through the region on a daily basis. Therefore, any environmental disaster is significant and will affect the economy of both countries. Finally, there are millions of people living in cities and towns in the Great Lakes region. Population growth continues and more people will be living in the region in the near future. As a result, people will be affected if an environmental disaster hit the region, anytime. It is difficult to assess the potential impact of an environmental disaster in the Great Lakes region because there is no disaster models exist aside from significant oil spills such as the simulation model of the Strait of Mackinac (See Section 4.5).

4.3.2 Potential Environmental Disasters Facing the Great Lakes

Participants were asked to identify the top five disasters that may potentially face the Great Lakes. All respondents mentioned toxic chemical and industrial releases and oil spills from various sources in their list. Sources of these environmental disasters from pollution events included: vessels, ships, pipelines and on-shore facilities. As discussed in Chapter 2, this category falls under human-made disasters. Moreover, four respondents mentioned invasive species in their list. Table 2 below provides a summary of the types of environmental disasters mentioned

by the eight officials interviewed. It is important to note that each respondent has a different list of environmental disasters in different order of significance. There was no agreement on a rank ordering from interviews so Table 2 summarizes those mentioned in interviews.

1. Oil spills	9. Storms	17. Thermo disaster
2. Invasive species	10. Erosion	18. Hydrocarbon
3. System failures	11. Harmful algal blooms	
4. Eco-terrorism	12. Climate change	
5-Hypoxia	13. Chemical pollution	
6. Chemical and industrial releases	14. Consequences of poor water quality	
7. Leaks from hazardous waste sites	15. Releases of untreated or inadequately treated sewage	
8. Flooding	16. Biological invaders	

Table 2: Summary table of the list of environmental disasters provided by respondents.

As noted above, participants at the GLEWS workshop identified numerous emerging stressors and threats in the Great Lakes and examples of these stressor and threats are listed in Table 1 above. In contrast, some of these emerging stressors and threats identified in interviews are outlined below in Table 2. For instance, aquatic invasive species, pollution events and climate change are listed in both tables. This reveals the importance of these environmental problems and experts who are working in the Great Lakes think they are significant. The lists in Tables 1 and 2 also indicate that it would be productive to develop a specific definition of environmental disaster that suits the context of the Great Lakes region and use risk perceptions and risk information to generate a ranking of various threats, stressors and potential environmental disasters as part of a comprehensive environmental disaster management framework as outlined in Figure 6, which could include a framework for future work on an early warning system.

Responses to this question about identifying the top five environmental disasters also shows that majority of respondents who represent major federal agencies are not thinking about significant or acute events as environmental disasters. In fact, the definition of disaster and environmental disaster for some respondents was not clear enough. It is a concern that the majority are familiar with environmental issues, threats and stressors but not thinking a lot about environmental disasters. One respondent elaborated on this concern:

“It is almost a human weakness, isn’t it? That we are better at dealing with things that [are] constant, continuing threats. We are not good at risks. The types of environmental disasters you are talking about, they have potentially huge impacts but it’s low probability. And people have difficulty somehow balancing that with something, which is lower risk but higher probability or actually ongoing. I think there is always an education component you have to do when you are talking about potential disasters” (Interview with a Canadian official, June 26, 2018).

It is surprising that none of the respondents mentioned hurricanes as a potential environmental disaster when the Great Lakes region has actually been subject to this type of disaster. The Great Lakes has experienced a couple of hurricanes historically such as 1913 White Hurricane and 1954 Hurricane Hazel. People tend to have a short memory when it comes to environmental disasters. Another observation is that eco-terrorism was mentioned by several respondents, which signals a real concern. The Great Lakes region is not familiar with type of disaster but it should receive more attention as a potential environmental disaster in the region. Since the Great Lakes hold roughly 21% of the world’s supply of surface freshwater, several noted that governments should be considering this as part of environmental disaster mitigation and preparedness in the region.

4.3.4 Factors That May Be Leading to an Increasing Number or Intensity of Environmental Disasters in the Region.

Participants were asked if there are any factors that may be leading to an increasing number or intensity of environmental disasters in the Great Lakes region. The majority of respondents stated that climate change is a significant factor. According to one participant, climate change causes a change in the frequency and temperature of high-energy weather-related events such as sudden large wind events. It also impacts the biology of the Great Lakes due to warming (Interview with a Canadian official author, January 30, 2019). One respondent discussed different factors in addition to the impacts of climate change. He states, “I worry that the science is not as well developed as it could be either and that hinders our ability to understand, predict and respond to environmental disasters”. Also, he mentions “Lack of binational coordination between our countries in terms of preparedness and response capabilities” (Interview with a Canadian official author, July 12, 2018). Additionally, four respondents argued that economic growth and an increase in population are two major factors.

Overall, the three main factors pointed out by the respondents based on their knowledge and experiences are climate change, population and economic growth. As discussed in Section 1, there is a relationship between climate change and disasters. Climate change increases the frequency, scale and scope of floods and shoreline disasters. It is predicted that hurricanes will increase as a result of climate change. These three factors were also considered significant also by GLEWS as mentioned previously.

4.3.5 Policies, Organizations, Programs and Specific Resources Related to Environmental Disasters Management in the Great Lakes Region

Participants were asked four questions, Q6 to Q10 in regard to the main policies, programs, resources and organizations, either transboundary or national for environmental disaster management in the Great Lakes (See Appendix A). The majority of respondents indicated that all levels of governments have different policies and programs in place. However, according to one respondent, the main policies and plans for environmental disasters are the Great Lakes Water Quality Agreement and there are two significant plans. The first plan is the Canada-United States Inland Pollution Contingency Plan. This plan is for Environment and Climate Change Canada and the US Environmental Protection Agency to work cooperatively on any boundary and transboundary pollution events that can affect both countries. The second plan is the Canada-United States Marine Pollution Contingency Plan. This is for Canadian and US Coast Guards to work cooperatively on oil spills and other releases on water (Interview with a Canadian official, June 26, 2018).

Overall, a review of the agreement and the two plans mentioned by interviewees reveals several findings. The GLWQA agreement does not include environmental disasters in any of its 10 Annexes. Only in Annex 5, prevention of oil spills and releases of hazardous polluting substances are addressed. However, other types of environmental disasters including natural and human-made are not included. Moreover, Canada-United States Inland Pollution Contingency Plan does not mention various environmental disasters. It only discusses the category of pollution incidents. Furthermore, Canada-United States Marine Pollution Contingency Plan is designed to prepare and respond to spills events in Great Lakes region, especially coastal areas. It does not discuss numerous environmental disasters, either. Therefore, the document review and interviews revealed that different types of environmental disasters such as hurricanes and flooding are not addressed in the GLWQA and the two existing binational plans.

Regarding major organizations that are related to environmental disaster management, the majority of respondents mentioned the following government organizations. For Canada, Public Safety Canada, Environment and Climate Change Canada, and Canadian Coast Guards. For the United States, Environmental Protection Agency, Federal Emergency Management Agency, US Coast Guards and National Oceanic and Atmospheric Administration. These are the main government actors that are responsible for environmental disaster management in the Great Lakes region according to the respondents. However, it was not evident that these organizations work together related to environmental disaster management or that these organizations work with the IJC's GLEWS working group.

4.3.6 Capacity to Anticipate and Respond to Environmental Disasters in the Great Lakes Region

Participants were asked about the capacity to anticipate environmental disasters in the region. One respondent thinks that it is adequate. He states “We do have a very sophisticated weather forecasting system in place. And it is working together between the two countries. Everyone is keen on weather so there is a lot of effort to making sure that we have good information about weather”. He adds, “Chemical pollution systems are more advanced and mature” (Interview with a Canadian official, July 11, 2018). On the other hand, the majority of respondents (7/8) think that the region does not have a good approach to anticipate. One participant remarks:

“That is a bit of a weak spot for us. As far as I know, there is not as much investment in ensuring the adequacy of infrastructure and others. In many cases, the science just is not there. For example, the science is not there with a high level of confidence to predict natural disasters like hurricanes, earthquakes etc. beyond just days and weeks. So, it is difficult to prepare for a large catastrophic event when you only have hours to get ready for it. Capacity is limited and there [are] a number of reasons for that relate to the

limitations of available science as well as it is just has not been a policy or program focused to ensure” (Interview with a Canadian official, July 12, 2018).

Participants were asked about the capacity to respond to environmental disasters in the Great Lakes region. One respondent mentioned that the capacity to respond is somehow limited. However, it all depends on the type of disasters. He noted:

“One way to assess this is the time needed to respond to a potential disaster. If there was a major oil spill in the Great Lakes; if you look at the distribution of the equipment that is placed in Canada, it will take a lot of time, too much time to respond quickly especially for spills. It is a matter of hours in the best scenario. Some of the equipment for the Great Lakes in terms of oil spills are located in Montreal, actually passes Montreal” (Interview with a Canadian official, January 30, 2019). This reveals a serious issue in regard to the efficiency to respond to oil spills in the Great Lakes region. There will substantial implications if a major oil spill takes place in Lake Ontario near Toronto taking into consideration the location of some of the equipment, which is in Quebec. If not responded quickly, it means more oil is discharged into the lake and that requires a lot of time to clean up, especially in the winter season when the lake is covered in ice. As a result, the ecological system of the lake is at a high risk due to this type of environmental disaster. However, the majority of respondents think that the capacity to respond is somewhat better than the capacity to anticipate.

Overall, most respondents (5/8) think that the capacity to anticipate and respond to oil spills in the Great Lakes region is satisfactory. There are some laws in place in each country, there is some scope in binational plans (the Canada-United States Inland Pollution Contingency Plan and Canada-United States Marine Pollution Contingency Plan) and some scope in the GLWQA agreement under Annex 5. Some felt there are experts and officers in place to deal with oil spills

in the region. The technology is there including advanced vessels equipped with high quality sensors and there are joint tests and practices going on in the region on a seasonal basis between the Canadian and American Coast guards. However, since there are no specific policies and plans that address various kinds of environmental disasters, it is extremely difficult to assess the capacity to anticipate, mitigate and respond to other types of environmental disasters in the Great Lakes region. The insights from interviews indicates there is some capacity related to environmental disasters that might occur from oil capacities but more limited capacity to anticipate and address many other potential environmental disasters.

4.3.7 The Need for a Binational Policy and Strategic Plan for Environmental Disaster Management in the Great Lakes Region

Participants were asked if there is a need for a binational policy, strategic plan or management systems for environmental disasters in the region. Three respondents discussed that there is no need for a specific policy related to environmental disaster management and it is already exists to a certain extent under existing binational plans and the GLWQA or scope under existing agreements and national policies.

However, the other five interview participants stated that definitely there is a need for a binational policy and strategic plans for environmental disaster management in the Great Lakes region. One US interviewee remarked: “Absolutely 100% there is a need. We do not work together as often as we should” (Interview with an American official, March 27, 2019). Another respondent indicated:

In the GLWQA Annex 10; there is the provision for scientist's assessment. We have not used it in a major way yet. We do not have the same provision on something like environmental disasters, where the two countries say that you know, we do not know enough about environmental disasters; let's do a major study. There is nothing to prevent us from doing that; we could just agree to do it. We were not fully insightful enough when

we renegotiated the GLWQA agreement in 2012 to build a mechanism that would allow us easily to trigger that” (Interview with a Canadian official, June 26, 2018).

For a few interviewees the scope already exists under the GLWQA and some Annexes. Four respondents expressed that an Annex to address environmental disasters including natural and man-made could be added to the GLWQA agreement in order to better mitigate, prepare, respond and recover from any type of environmental disasters in the Great Lakes region. Furthermore, five participants expressed that strategic plans for various types of environmental disasters can be developed to better prepare for the future. Strategic plans that build on GLWQA or the two existing binational plans (the Canada-United States Inland Pollution Contingency Plan and Canada-United States Marine Pollution Contingency Plan) as possible models.

4.3.8 The Response in the Case of a Transboundary Environmental Disaster in the Great Lakes

Participants were asked if we have a transboundary environmental disaster such as an oil spill or nuclear disaster, what is going to happen. The majority of respondents (6/8) mention that it all depends on the type of environmental disaster. According to a respondent, “In Canada the Federal Nuclear Response Plan will be activated in the case of a nuclear event. And the Canadian Nuclear Safety Commission will take a lead on this” (Interview with a Canadian official author, May 14, 2019). In the case of an oil spill, five of the respondents mention that Canada-United States Marine Pollution Contingency Plan would be activated. Overall, a binational policy or plan for nuclear disaster was not mentioned or discussed by the respondents.

In conclusion, participants were asked if they think the Great Lakes region needs to develop more policy capacity to deal with environmental disasters in the future. Two respondents think that it is not necessary. The other six respondents think that the region needs

to develop additional policy capacity for environmental disasters in the future. This matches with the majority of experts at the GLEWS Workshop who also expressed that the region needs to build more capacity to address environmental threats and stressors in the future.

4.4 Findings from GLEWS Consultant's Report

The report following the GLEWS workshop based on hiring consultants was published in November 2018, which includes an overview of the project, summary of current state and knowledge of environmental stressors and threats in the Great Lakes (Donahue and Slaweck, 2018). The report includes an overview of the GLEWS workshop and details on the discussions and findings from the workshop, which were discussed in the previous section 4.2. It mentions numerous stressors that exist in the Great Lakes such as habitat loss and chemical contamination in Lake Superior; sedimentation and aquatic nuisance in Lake Michigan; costal pollution in Lake Huron; point source pollution in Lake Ontario and invasive species and algal blooms in Lake Erie.

The report presents findings from the GLEWS workshop and subsequent research, literature review, surveys and interviews with experts related to current knowledge about early warning systems and alternative frameworks for a Great Lakes Early Warning System. The frameworks in the report build on those that were tabled at the GLEWS workshop including establishing an annual conference to identify emerging and predicted threats and stressors, establishing GLEWS subcommittee within the IJC and forming a new independent organization. It states, "The recommended framework calls for the initial development of a distinct and formalized entity, namely, a subcommittee of the SAB within the IJC structure, supported by one or more IJC staff" (Donahue and Slaweck, 2018).

In addition, this recommendation indicated a GLEWS subcommittee of the IJC SAB could be responsible for five major missions. First, identify and monitor existing, progressing and

predicted stressors and threats in the Great Lakes. Second, prioritize the threats and stressors according to their ecological and socio-economic effects. Third, recommend mitigation and response plan to tackle those environmental stressors and threats. Fourth, document those plans when implementing and their consequences. Fifth, address gaps and barriers that prevent the accomplishment of the first and second mission in the Great Lakes region.

The consultant's report mentions the recommended next steps for the project, which includes the formation, operation and evaluation of GLEWS in the next two years. It also recommended how GLEWS could be advanced in the upcoming months through meetings of GLEWS working group members and updates on a quarterly basis; holding a minimum of one conference that focuses on environmental stressors and threats; and publishing an annual report to outline GLEWS actions and achievements (Donahue and Slawewski, 2018).

Finally, the recommended framework of establishing a subcommittee of the Science Advisory Board within the IJC structure or in some other alternative form seems to be significant to advance work on GLEWS, and potentially incorporate a focus on environmental disasters in the future. The SAB and the IJC as a transboundary organization is capable and has the experience of implementing special projects like GLEWS given the science-based focus of the IJC and its SAB and WQB. From the GLEWS workshop and a review of the consultant's report it is evident that the scope of GLEWS could include environmental disasters as part of future work on an early warning system in the region. This is particularly relevant related to possible environmental disasters such as flooding, oil spills, or other potential environmental disasters in the future due to climate change and other factors.

GLEWS could be the foundation of developing a general/comprehensive environmental disaster management framework that could include clear definitions of environmental disaster, threats, stressors, some identification of risk/probability, some discussion of governance arrangements and a more explicit focus on environmental disaster management in the region.

The GLEWS discussion of a framework might also lead to issue specific plans underneath a framework. An illustrative case study indicates how this could be important.

4.5 Findings from Illustrative Case: Enbridge Gas Line 5 in the Straits of Mackinac

A review of several secondary documents and participation in the GLEWS workshop in 2018 related to environmental threats and issues in the Great Lakes region led to a major finding. Enbridge Line 5 in the Straits of Mackinac Island represents a good example of a potential transboundary environmental disaster in the Great Lakes region. This section uses this case to illustrate the current state of environmental disaster management in the Great Lakes region related to the central research questions.

The straits of Mackinac in the state of Michigan are a waterway located in the Great Lakes, between the upper and lower peninsulas of Michigan. The major strait is located under the Mackinac Bridge and connects two of the Great Lakes, Lake Huron and Lake Michigan, into one hydraulic system (Schwab, 2016). The waterway of the straits is approximately 10 km in length. Furthermore, currents in the straits cause a reverse in direction between the east and west flowing every couple of days. The strength of these currents is as much as the currents in the Detroit River, which is up to 1 m/s. (Alexander and Wallace, 2013; Schwab, 2014). The straits of Mackinac are capable of generating powerful currents that produce a flow of water, which is more than 10 times the flow of the Niagara River 80,000 m³/s (Schwab, 2016). The flow in the straits is important for navigation, contaminant transport, water quality and ecological processes (Saylor and Sloss, 1976; Schwab, 2016).

The Great Lakes region is vulnerable to a potential disaster of oil spill. Line 5 oil pipeline is located at the bottom of the Great Lakes in the straits of Mackinac, which was built by Canadian company Enbridge Inc. in 1953 (Alexander and Wallace, 2013; Schwab, 2016). Line 5 as shown in figure 6 carries roughly 20 millions gallons of light synthetic crude oil, natural gas liquid and light

crude oil across the straits everyday. Line 5 transports oil for 645 miles (1,038 km) in 20 inch diameter pipe, from Superior, Wisconsin to Sarnia, Ontario passing through the straits of Mackinac (Melstrom et al., 2019; Schwab 2016).



Figure 7: Enbridge Line 5 (Schwab, 2016).

Line 5 pipeline is operated and maintained by Enbridge Oil Company. In fact, this pipeline has a life expectancy of 50 years, which means that the pipeline has been operating for 17 years without any replacement (Schwab, 2016). Enbridge has installed some support structures beneath the pipeline since 2003, which is the expiry date of the pipeline. However, the public records of the company show that Enbridge has over 800 oil spills from 1999 to 2010 in North America (Schwab, 2016). Thus, this triggers a real concern for the public when it comes to the environment and safety. Additionally, there will be a huge effect in the Great Lakes basin if this pipeline breaks at any moment.

Several computer simulations were done to determine the worst-case oil spill scenarios in the straits of Mackinac by using a hydrodynamic model (Schwab, 2016). These simulations show that a total of 720 miles (1,159 km) of shoreline in Canada and the US is vulnerable to potential

oil spill. The areas and communities at the highest risks include Beaver Island, Mackinac and Bois Blanc Islands, Cross village, locations along Lake Huron and Lake Michigan shoreline, west and east side of Mackinac city (Schwab, 2016). The simulations show oil in the surface in approximately 60% of the open water of Lake Huron. Moreover, the shortest arrival time for visible surface oil is 2.5 hours. Certain characteristics of crude oil were considered in the simulations such as dispersion properties, gravity and evaporation rate (Schwab, 2014, Schwab 2016). Also, three different spill volumes were measured in the worst-case discharge in the straits of Mackinac, which are 5,000 barrels, 10,000 barrels and 25,000 barrels (Schwab, 2016).

However, this case illustrates a couple of arguments that are associated with environmental disaster management in the Great Lakes region and this thesis. First of all, some people from the Great Lakes region including scientists, engineers, NGOs, bloggers and others discussed and spoke about the potential environmental disaster from Enbridge Line 5 since it had expired in 2003. However, neither the State of Michigan nor Enbridge took actions to address this potential environmental disaster until late 2012. After 2012, Enbridge Line 5 had received a lot of attention, which brought significant pressure upon Enbridge. Some videos were uploaded on YouTube, which showed cracks and repairs of strips to the pipelines at the bottom of the lakes. As a result, risk assessments were done to evaluate the concern and respond to this potential threat.

In the past year there has been a major development in regard to Enbridge Line 5 and the company agreed with the approval of the State of Michigan to build a tunnel underneath the straits of Mackinac where the pipelines operate as a solution to this problem. To date there is no indication if this solution will address the issues and controversy related to the deteriorating state of oil pipelines in the lakes and avoid a potential environmental disaster.

This case raises some important questions. Why did the federal and State/Provincial governments wait for almost 10 years to do something about this potential environmental disaster in the region? Were they not aware of the issue and potential risks? Or is it too expensive to address the mitigation required? Another question, if there was no attention or awareness among the public about the potential environmental disaster from Line 5, would there be any action taken by the State of Michigan or Enbridge to respond? Is there reason for other jurisdictions in the region to be concerned? Is this a local, state, national or transboundary issue? These questions lead to some indication that the governance arrangements for this type of environmental disaster are not sufficient. The Canada-United States Marine Pollution Contingency Plan is the plan that is responsible for oil spills on water in the Great Lakes. However, the plan is more of a response and recovery focus instead of mitigation and preparedness. The plan does not anticipate environmental disasters and does not have an early warning system component to be proactive towards disasters. Also, this plan came into force in 2017 so it is a recent agreement and has not been implemented related to different potential environmental disasters in the Great Lakes yet.

Secondly, this case illustrates the extreme importance of a binational approach for environmental disaster management in the Great Lakes region. Any potential environmental disaster such as oil spills from Line 5, will affect both countries due to the transboundary location of the pipelines. A binational approach for environmental disaster management will help to identify various potential environmental disasters in the region in order to better prepare for them by developing mitigation & responding strategies and plans ahead of time.

This case also indicates that government organizations and actors are only part of the governance regime and capacity related to environmental disaster management in the region. There are some important non-governments initiatives that have existed for years. For example, Transportation Community Awareness and Emergency Response (TRANSCAER) is an initiative,

which was created in 1986 to provide knowledge, training and necessary tools for emergency responders to respond to emergencies effectively (TRANSCAER, 2016). It focuses on transportation events that are related to hazardous materials. “Working with its network of volunteers, TRANSCAER offers events across the United States and Canada that include training on actual rail and truck equipment, live release drills, and table-top exercises to discuss possible emergency situations. It offers hundreds of training events each year that are free and open to the emergency services community” (TRANSCAER, 2016). The Government of Canada through Transport Canada invested in TRANSCAER with \$ 219,750 recently to promote rail safety (Government of Canada, 2020). Another example that was introduced by the Chemistry Industry Association of Canada in 1985 called Responsible Care, which is considered as a non-state rule instrument that contributed in the Remedial Action Plans for the Great Lakes Areas of Concerns (Martin and Webb, 2020). These initiatives highlight that starting with a focus on government-led environmental disaster management is only a start and that it is important to outline how non-government organizations and initiatives fit into a multi-level, transboundary environmental disaster management framework.

Finally, this case study highlights that further research is required to more fully assess the extent to which the region is prepared to respond to different potential types of environmental disasters that may face the region in the future. The case highlights that each potential type of environmental disaster requires some issue-specific focus and risk analysis. Thus, risk management approaches, intergovernmental and network management approaches are required to mitigate and prepare for transboundary oil spills and other environmental disasters in the Great Lakes.

5.0 Conclusion and Recommendations

This thesis explores the state of government environmental disaster management in the Great Lakes region of North America. A review of academic literature and secondary sources was conducted to understand definitions, states and different components of environmental disaster management in the Great Lakes. Through document analysis, a couple of major findings were discovered in related to the research questions. The key informant interviews also provided some very important information and findings related to the research questions. This conclusion summarizes the key findings of this thesis.

This thesis indicates there is a need for a clear and working definition of environmental disaster in the Great Lakes. A specific environmental disaster definition for the Great Lakes region is needed due to the following reasons. First, there is no existing definition of environmental disaster within federal, provincial/state and municipal organizations across the region so far. Starting with some definitions helps to have a clear understanding of environmental disaster among various stakeholders in the region. It also helps to determine what qualifies as an environmental disaster and what not and how environmental disasters relate to other key concepts like threats and stressors. For example, is the presence of an invasive species an environmental disaster? Would climate change be considered as an environmental disaster or one of many factors making environmental disasters in the region more likely? The Great Lakes are a unique ecological system that requires significant mitigation, preparedness and response strategies. Thus, a specific working definition of environmental disaster in the region is needed, which takes into consideration the extraordinary ecological and environmental features of the Great Lakes.

The findings from this research reveal that the IJC's GLEWS working group is a starting point. The GLEWS working group has the capability to come up with a solid and working

definition of environmental disaster that suits in the context of the Great Lakes region and to bring an expert focus to environmental disaster management, if the scope of GLEWS is broadened somewhat. Incorporation of additional perspectives and experts of emergency management, social science and Indigenous perspectives on GLEWS would make the focused more interdisciplinary and would expanded the scope from a focus on ecological threats and stressors to include some work on environmental disaster management as part of an early warning system in the Great Lakes region.

The final report of GLEWS working group will be published in Spring 2020. However, the findings from this research indicate that a focus on environmental disaster management could be dealt with in future workshops and reports of GLEWS. The same approach that was applied in the workshop in 2018 could be used again to bring scientists and various experts and stakeholders together in a two-day workshop to discuss and propose a working definition for environmental disaster in the Great Lakes region and discuss how environmental disaster management could fit into a Great Lakes early warning system related to the GLWQA. Those working on the two existing binational plans and emergency management leaders could be incorporated. The IJC is well positioned to do this work given the existence of GLEWS as a working group under Science Advisory Board and the potential to work more closely with the IJC's Water Quality Board. Through the work of GLEWS, the starting point should be a definition of environmental disaster that can be the foundation of a framework and future progress at all levels of governments in the region.

Findings from this research also reveals that environmental disasters are not listed in any of the Annexes of the Great Lakes Water Quality Agreement aside from spills in Annex 5. Each Annex of the GLQWA focuses on a certain component of environmental concerns in the Great Lakes region. It is quite challenging to expand any of the annexes to include environmental disasters since the topic is a large and significant environmental concern in the Great Lakes that

crosses several annexes. For instance, Annex 4 focuses on nutrients and the purpose of this annex is to manage phosphorus concentrations and other nutrients if existed in the Great Lakes. This annex is already narrowed and specific to deal with a specific environmental concern. Thus, it is not feasible to broaden this and other annexes to cover various environmental disasters such hurricanes and flooding.

There is scope in Annex 9 on Climate Change or Annex 10 as it focuses on Science and both deal with cross-annex issues. The GLEC committees for these annexes have had some important foci on mitigation and preparedness. The alignment with IJC's work on GLEWS however is not clear. There seems to be potential here to align the work of GLEWS more closely with the GLEC subcommittees on environmental disaster management. Perhaps the workshop model used by GLEWS could be used to bring these two communities of practice together along with disaster management experts to focus on environmental disasters, threats, stressors and further work on early warning systems.

In the longer term, this thesis recommends a specific Annex to be added to the Great Lakes Water Quality Agreement that addresses different types of environmental disasters in the region. The Great Lakes region has faced numerous environmental issues such as pollution, contaminants, invasive species and chemical and oil spills. These issues were dealt with as they arose and became significant. Different levels of governments have responded to these issues through introducing policies and programs and implementing them, founding committees and working groups and other arrangements. These actions were implemented over a period of time to address various environmental problems. A specific Annex for environmental disasters could help to focus mitigation and preparedness work on a wide range of potential disasters, threats and stressors in the Great Lakes region.

A new Annex could be the foundation for different federal, state and provincial organizations to work together under the Great Lakes Executive Committee structure to when it

comes to environmental disaster management in the Great Lakes region. In addition, the Environmental Disaster Annex could be an effective approach to introduce a proactive rather than reactive approach when it comes to environmental disasters and issues. The environmental disaster literature clearly shows that a disaster has to hit somewhere then relevant governments will be involved and respond accordingly. This reactive approach has proved to be costly and ineffective when it comes to environmental disaster management. Increasingly governments are trying to take more proactive approaches and invest in some strategic and scenario thinking related to environmental disasters, particularly in the context of climate change. A renewed GLEWS focus or a new environmental disaster Annex could be the foundation for building binational discussion and a community of practice for future development of protocols and strategic programs for potential environmental disasters in the region, particularly focused on mitigation and preparedness.

Major findings from the key interviews that were conducted in this research indicates that potential environmental disasters are considered significant in the Great Lakes according to the expert participants. They are significant due to the importance of the Great Lakes not only to Canada and the US, but also to the entire world. The region is the largest single drinking water in the world; it provides millions of jobs for both countries; significant economic wealth; ecological supports and services; and social, cultural and spiritual significance to the millions of people living in cities, towns and communities in the region.

There are a number of factors that indicate there needs to be an increasing focus on the potential for disasters in the region. The three main ones mentioned by the respondents were climate change, population and economic growth. Indeed, this finding from the key informant interview matches with the finding from the GLEWS workshop. Future work of government organizations related to environmental disaster management should focus on all of the three factors, especially climate change. Studies show climate change increases the frequency of

environmental disasters such as flooding. Immigration in Canada and the US will increase the population in the region significantly by 2050, particularly in cities on the shorelines of the Great Lakes. The economic significance of the region will also increase as a center of clean energy, unparalleled natural resources, and transportation.

Findings from the key informant interviews and the illustrative case study of Enbridge Line 5 show that the region does have some capacity to manage environmental disasters related to oil and hazardous spills. Some relevant agreements, policies and plans do exist. The Canadian and US governments have binational agreements and plans that are relevant but they are not connected to any transboundary or regional thinking about environmental disaster management. Some are covered in the GLWQA, and the focus of the IJC and GLEC, others are covered in the Canada-United States Inland Pollution Contingency Plan and the Canada-United States Marine Pollution Contingency Plan. However, the findings reveal the Great Lakes region is likely not prepared and does not have the capacity to manage other types of potential regional environmental disasters.

The region needs to develop additional capacity for environmental disaster management in the future. The Canada-United States Inland Pollution Contingency Plan and the Canada-United States Marine Pollution Contingency Plan are not sufficient. These two plans only address a specific type of environmental disasters, which are spills. The scope of these two plans is limited and does not include various environmental disasters such as hurricanes and floods. There is a need to develop additional capacity both to anticipate and respond to environmental disasters and there is a need for binational policies and strategic plans for environmental disaster management in the Great Lakes region. The capacity to anticipate and respond consists of both technical and governance components. On the technical side, it includes science, early warning systems and local response and recovery. On the governance side it requires transboundary risk

assessment, framework development and possible coordination of existing policy instruments and government arrangements to address environmental disasters.

Overall, this research found that there is a need for binational strategic thinking, planning and coordination in regard to environmental disaster management in the Great Lakes. The IJC, US Environmental Protection Agency and Environment and Climate Change Canada can take the lead by first determining who in these agencies has the expertise and a role in environmental disaster management. Perhaps this could be the foundation of advancing GLEWS or another IJC working group to bring environment and disaster management officials into a discussion. The IJC can play a leadership role given its advisory role to both governments and its previous work through GLEWS as a binational working group, or perhaps a separate working group on environmental disaster management. An important aspect of this collaboration would be to develop a clear definition of environmental disaster and a comprehensive disaster management model for the Great Lakes similar to the one outlined in Figure 6. It is clear from the international literature on disaster management and environmental disaster management, the components and activities in the Great Lakes environmental disaster model will be different in comparison to other regions. Yet, definitions and this type of model are helpful starting points for developing an environmental disaster model for the Great Lakes region in the future.

This study was exploratory. The findings from this study indicate there is a need for future research. Future research could focus on the policy capacity of different government organizations to anticipate and respond to different environmental disasters in the Great Lakes region. Future research could also focus on a more collaborative approach to environmental disaster management. The Great Lakes has a complex, multi-level, multi-organizational, multi-actor governance system and there are challenges related to transboundary and binational coordination in such a complex system. “The IJC has not overcome the fundamental problem of coordination between the two federal governments and the respective sub-national governments

that has plagued attempts to protect the Great Lakes basin ecosystem because it was not vested with the power to do so” (Jetoo et al., 2015). The GLWQA and Annexes have been shown to focus efforts by the IJC and Canadian and US governments on important issues facing the region and get a wide range of agencies to work together on important issues. Environmental disaster management is one topic that has not received much attention and only recently has the IJC established GLEWS and other proactive approaches and frameworks.

This research study focused on mitigation and preparedness by governments. It is important to note that future research could also focus on response and recovery and all governments and non-government arrangements related to environmental disaster management in the region. Also, a comparative research approach could be an important frontier of future research related to regional approaches to environmental disaster management and lessons for the Great Lakes region. Furthermore, a risk management approach to environmental disasters in the Great Lakes could be another focus of future research to clearly understand and assess the probability and impacts of different environmental disasters in the region. Different environmental disasters in the Great Lakes are considered low probability such as earthquakes but pose catastrophic impacts if they occur. Risk analysis of these environmental disasters taking into consideration the factors of climate change and regional change are extremely important to further investigate environmental disaster management in the Great Lakes region. While this research was exploratory, hopefully the findings from this research and future research may help advance knowledge and practice related to any environmental disasters that may threaten the sustainability of this significant ecological region in the future.

Appendix A: Interview Questions

1. What is your background and current role?
2. Can you tell me about your experience related to environmental disasters in the Great Lakes region?
3. In your opinion, how significant are environmental disasters in the Great Lakes region?
4. In your opinion, what are the top five disasters that may potentially face the Great Lakes Region?
5. In your opinion, are there any factors that may be leading to an increasing number or intensity of environmental disasters in the region?
6. What are the current domestic environmental disaster policies and programs in the region?
7. What are the most significant domestic organizations in (Canada/the US) related to environmental disaster management?
8. What are the current transboundary/binational environmental disaster policies and programs in the region?
9. Are there specific organizations, committees, working groups or networks for environmental disaster management in the Great Lakes region?
10. Are there specific resources (funding, research grants, personnel) that are allocated towards environmental disaster management in the Great Lakes?
11. What is the capacity to anticipate environmental disasters in the region?
12. What is the capacity to respond to environmental disasters in the region?
13. In your opinion, is there a need for a strategic binational plan, policies or management systems for environmental disaster management in the region?
14. If we have a transboundary environmental disaster in the region what will happen?
15. For example, if there was a transboundary nuclear disaster or oil spill in the region, what would be the response?
16. Do you think the region needs to develop more capacity to deal with environmental disasters in the future? Why? Why not?
17. Is there anything else that you would like to add, which was not included in the previous questions?
18. Are there other people that you recommend I interview?
19. Would you like to receive a copy of the interview notes or transcript?

Appendix B: Recruitment Email

Dear [Name]:

My name is Abdullah Alotaibi and I am a Master Student in the Environmental Applied Science and Management Program at Ryerson University. I am working under the supervision of Dr. Carolyn Johns. We are conducting a research study about environmental disaster management in the Great lakes and to investigate how prepared the region is. I am emailing to ask if you would like to be interviewed online for an hour to answer a list of questions for this research project. Participation is completely voluntary and your identification information will be anonymous.

If you agree to participate, I will interview you online for approximately one hour. I will be asking questions related to potential environmental disasters in the Great Lakes, as well as what are the current systems and policies in regard to environmental disaster management in the region.

I have attached a consent form to this email, which contains all the information in regard to this study and your rights as a participant. Please read it and feel free to ask any questions. By agreeing to participate in the study, it confirms that you have read and understand your rights as a participant.

I will follow up with you shortly to ask if we can schedule an interview date whenever you are available.

If you any questions please feel free to email or call me.

I sincerely appreciate your time and looking forward to your reply.

Abdullah Alotaibi
aalotaibi@ryerson.ca

Appendix C: Participant's Research Consent Form

Environmental Disaster Management in the Great Lakes: To what extent is the region prepared?

You are being asked to participate in this research study. Please read the following information prior to giving your consent to be a volunteer. Feel free to ask questions to make sure things are understood and clear. Contact information is provided below.

Investigators:

This research is being conducted by Abdullah Alotaibi, a Master student in the Environmental Applied Science and Management Program at Ryerson University. Abdullah is working under the supervision of Dr. Carolyn Johns, an Associate Professor in the Department of Politics and Public Administration at Ryerson University.

Purpose of the study:

This research is being done as part of my Masters for the completion of the Master program of Environmental Applied Science and Management.

The purpose of this study is to explore, document and analyze the state of environmental disaster management in the Great Lakes region. The project seeks to answer the following questions: To what extent is the Great Lakes Region prepared for and does it have the capacity to manage transboundary environmental disasters? What transboundary, US and Canadian arrangements exist relate to environmental disaster management in the Great Lakes region? To what extent do existing systems anticipate and mitigate environmental disasters in the Great Lakes? Is there a need for a cooperative transboundary system related to environmental disaster management in the region?

Description of the study:

Participants with environment and disaster management expertise are being invited to participate in this study. 60 people are invited, 20 are expected to participate. Once you submit your consent to participate in this study by signing and returning this consent form via email, you will be interviewed on your knowledge and experience related to environmental disaster management in the Great Lakes region. You will receive a list of the interview questions prior to your scheduled interview. The interview will take a place online through Zoom via an online video call at an agreed date and time. The interview will take approximately 45 minutes to 1 hour of your time.

Potential Benefits of the Study:

In terms of the potential benefits of the study, there are no direct benefits that you will gain from participation. However, this research study will contribute to the literature of environmental disaster management. It will identify the current state of environmental disaster management in the Great Lakes in terms of mitigation and preparedness. Also, this research study will provide information on the top five potential disasters that might face the region, which will help the stakeholders in terms of disaster anticipation and preparedness.

Potential Risks:

There are very low potential risks associated as a result of participating in this study such as possible discomfort related to participating in the interview and the risk of you and your responses not remaining confidential and potential negative implications of this. In order to minimize the possibility of experiencing discomforts in the interview, the questions will be sent to you in advance. This will give you time to prepare and be comfortable with the questions. In addition, your participation and your responses will be confidential.

Confidentiality:

All of your responses will remain confidential and not be directly or indirectly attributed to you in the thesis or any publications that may follow the thesis. You will not be identified by name and none of your personal information will be included in the thesis.

Interview notes and transcripts will be labeled with a number and identifying information will not be included in the files. Confidentiality will be ensured by protecting the encryption and passwords of the interview computer files. No one will have access to the files and the content of the interview aside from the investigator and Dr. Carolyn Johns.

Voluntary Nature of Participation:

Your participation in this study is totally voluntary. Your choice of whether or not to participate will not influence your future relations with Ryerson University. Once you agree to participate, you can withdraw and stop your participation at any time with no penalty. You can refuse to answer any question during the interview. All records and copies of your response will be deleted if you decide to withdraw.

Data Storage:

Audio-recordings will be stored in a password protected computer file; they will be transcribed into notes as soon as possible after the interview, participants will be given a participant number and all identifying information will be removed from the transcript, and then the audio recording deleted. Notes will be stored in a password protected computer file until the thesis is defended; the notes will then be destroyed by September 30, 2019.

Data Dissemination:

Data will be stored in a digital file on my computer and will only be shared with my supervisor Dr. Carolyn Johns. Participants can access the final thesis online.

Use of Recording device or software:

Zoom software will be used to conduct and record the interview. There is a recording feature in Zoom, which allows you to record the entire interview. After recording the interview on Zoom, it will be transcribed into notes, the recording will then be deleted and the notes stored in a password protected computer file.

Recording the interview and the use of a recording device is highly recommended due to the fact that it helps with the accuracy and the precision of the transcription of your interview responses. However, you can decline from having your interview recorded. If you decline audio-recording, I will only record your responses by hand.

The audio-recording will be deleted immediately following the transcription of your responses into notes. Only the transcribed notes with your participant number and no identifying information will be used in data analysis. The transcribed notes and any hard copy notes taken during the interview will be destroyed within one year after the completion of the Master's thesis, by September 30, 2019.

Please check one of the options below:

☐ **I consent to the use of a recording device throughout the duration of my interview.**

☐ **I wish to have my responses recorded by hand only.**

Questions about the Study:

If you have any questions about this research study, your participation, or this consent agreement, you may contact me or my supervisor:

Abdullah Alotaibi
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Department of Politics and Public
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Ryerson University
416-979-5000 x 6146
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If you have questions about your rights as human subject and participant in this study, you may contact the Ryerson University Research Ethics Board for information:

Research Ethics Board
c/o Office of the Vice President, Research and Innovation
Ryerson University
350 Victoria Street
Toronto, ON M5B 2K3
416-979-5042
rebchair@ryerson.ca

Agreement:

Your signature below indicates that you have read the information in this agreement and have had a chance to ask any questions you have about the study. Your signature also indicates that you agree to participate in the study and have been told that you can change your mind and withdraw your consent to participate at any time. You have been given a copy of this agreement.

You have been told that by signing this consent agreement you are not giving up any of your legal rights.

Name of Participant (please print)

Signature of Participant

Date

Signature of Investigator

Date

Appendix D: GLEWS Workshop Participant List

1. Lucinda Johnson, University of Minnesota Duluth
2. Michael Twiss, Clarkson University
3. Gavin Christie, Fisheries and Oceans Canada
4. Patricia Chambers, Environment and Climate Change Canada
5. Christine Mayer, University of Toledo
6. Val Klump, University of Wisconsin - Milwaukee
7. Ian Campbell, Agriculture and Agri-Food Canada
8. Kyle McCune, United States Army Corps of Engineers
9. Carol Miller, Wayne State University
10. Michael Murray, National Wildlife Federation
11. John Livernois, University of Guelph
12. Joe DePinto, Independent Consultant
13. Gail Krantzberg, McMaster University
14. Kathryn Friedman, State University New York, University at Buffalo
15. Mark Fisher, Council of the Great Lakes Region
16. Carolyn Johns, Ryerson University
(I attended on her behalf with the approval of the IJC)
17. Al Steinman, Grand Valley State University
18. Kate Bassil, Toronto Public Health
19. Marvourneen Dolor, Ocean Collective
20. Dale Phenicie, Council of Great Lakes Industries
21. Norm Granneman, (retired) United States Geological Survey
22. Henry Lickers, (retired) Mohawk Council of Akwesasne
23. Matthew Child, International Joint Commission (Great Lakes Regional Office)
24. Lizhu Wang, International Joint Commission (Great Lakes Regional Office)
25. Victor Serveiss, International Joint Commission (US Section)
26. Robert Phillips, International Joint Commission (Canadian Section)
27. Mike Donahue, AECOM
28. Tad Slawecki, LimnoTech

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