EXAMINING THE SOCIAL AMPLIFICATION OF RISK IN GREAT LAKES AREAS OF CONCERN

BY

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THESIS

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ABSTRACT

Waterways around the Great Lakes are undergoing sediment remediation work to remove legacy industrial pollutants in International Joint Commission-designated Areas of Concern. While pollution remediation provides clear benefits to human and environmental health, the social impacts of the cleanup process in AOC communities is less clearly understood. This project examines how and to what degree the social amplification of risk framework (SARF) can be used to identify differences in the public understandings of the risks posed by contaminated sediment before and after remediation work is completed, as well as between geographic locations, to improve environmental outreach and public understanding communication in AOCs.

Chapter 2 investigates the viability of the SARF as a tool for secondary analysis of interview data about waterway remediation work. I test the framework against risk perceptions shared in stakeholder interviews conducted before and after sediment cleanup was completed in the Sheboygan River AOC in Sheboygan, Wisconsin. Findings indicate that the SARF is an effective analytical lens for examining how risk information about waterway pollutants travels through communities, and successfully identifies differences in those patterns of risk information before and after remediation is complete. Chapter 3 applies the SARF to three different AOC sites that have yet to undergo remediation work: The Upper Trenton Channel in the Detroit River AOC, MI, the U. S. Steel Site in the St. Louis River AOC, MN, and the Zephyr Site in the Muskegon Lake AOC, MI. The risk amplification models produced by each site suggest a degree of congruence in which actors within AOC communities are key sources of risk information, the effect of pollution visibility on public perceptions of risk, and the types of negative impacts stakeholders identify as a result of contamination. However, distinct differences in the models produced by each site suggest generalization may be limited, and that each AOC has unique communications needs informed by local politics, geography, and the nature of the pollutants at each site.

By identifying how risk messages pass through different information channels in each of the four communities included in this study, a better understanding of the factors which influence public perceptions of the pollutants and their remediation is produced, generating new insights on best practices for stakeholder outreach. The social amplification of risk framework is demonstrated to be a valuable tool for mapping public perceptions of waterway risk in AOCs, and illuminates both common ground and areas of difference between sites and over time, providing a richer understanding of communications needs for environmental professionals working with AOC communities.

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TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION ……1

CHAPTER 2: EXAMINING THE SOCIAL AMPLIFICATION OF RISK IN THE SHEBOYGAN RIVER AREA OF CONCERN ……17

CHAPTER 3: EXAMINING THE SOCIAL AMPLIFICATION OF RISK IN THREE GREAT LAKES AREAS OF CONCERN ……36

CHAPTER 4: CONCLUSION ……67

REFERENCES……79

APPENDIX A: PROJECT CODE TABLES ……84

APPENDIX B: IRB DOCUMENTATION ……90

APPENDIX C: SUPPLEMENTARY MATERIAL ……91

CHAPTER 1: INTRODUCTION

Waterways around the Great Lakes are undergoing sediment remediation work to remove legacy industrial pollutants in Areas of Concern (AOCs). While pollution removal provides clear benefits to human and environmental health, the social impacts of the cleanup process in AOC communities is less clearly understood. This project uses the social amplification of risk framework (SARF) to examine differences in the public understandings of the risks posed by contaminated sediment before and after remediation work is completed, as well as between geographic locations. By identifying how risk messages pass through different information channels in each of the four communities included in this study, a better understanding of the factors which influence public perceptions of the pollutants and their remediation may be produced, generating new insights on best practices for outreach and communication for environmental professionals working with AOC communities.

Stakeholder involvement in environmental decision-making has been shown to improve the quality of decisions, the relationships among important players in the process, the capacity for managing environmental problems, and environmental quality itself (Bieirle and Konisky, 2001). To facilitate this public involvement, effective communication and outreach about the environmental issue in question is needed from environmental specialists (Tucker et al, 2008). Establishing what stakeholders know about the environmental issue in question, how they feel about it, and where they get their information about it are all important when designing communications plans for a community – and I posit that all of these factors are able to be identified and examined through the application of the SARF.

I set out to examine the question: **what can the social amplification of risk framework reveal about risk perception and communication about sediment contamination in Great Lakes Areas of Concern?** Over the course of two chapters, I aim to understand:

1. whether SARF is a useful framework for examining risk perception surrounding legacy sediment contamination, and, if so,
2. how the application of SARF may offer support for a general set of best practices for communication around AOC remediation over the chronological course of cleanup work and between different geographic locations.

Chapter 2 will test the viability of the social amplification of risk framework as a tool for secondary analysis of interview data about waterway remediation work, and will center on a comparison of the risk models produced by stakeholder interviews conducted before and after sediment

cleanup was completed in the Sheboygan River AOC in Sheboygan, Wisconsin. Chapter 3 will apply the SARF to three different AOC sites that have yet to undergo remediation work: The Upper Trenton Channel in the Detroit River AOC, MI, the U. S. Steel Site in the St. Louis River AOC, MN, and the Zephyr Site in the Muskegon Lake AOC, Muskegon, MI. This second chapter will identify the similarities and differences in the risk amplification models produced by each site in order to gain a better understanding of how risk information travels through different AOC communities and what generalizations, if any, might be made to guide future communications strategies for environmental professionals.

Literature Review

Hazards and risks

The study of risks and hazards is a fundamental component of understanding how humans are influenced by and react to their environment, particularly in the post-industrial age. In *Risk Society: Towards a New Modernity,* Ulrich Beck argues that science and technology have created a multitude of new hazards that did not exist earlier in human history, and that risk is in fact a defining characteristic of the 20th century and beyond (Beck and Ritter, 2010). Legacy industrial pollutants in waterway sediments are an ideal example of this concept: novel, technologically produced hazards with far-reaching consequences for human and environmental health. Understanding how stakeholders perceive risk and how hazard managers can communicate about it most effectively is thus crucial to the success of any environmental remediation work.

Defining *risk*, however, has long been a topic of debate among even risk communicators themselves. The common technical definition of a risk as "hazard plus vulnerability" (Lundgren, 2013) has been critiqued for not sufficiently describing the social impacts of said risk based on public *perception*, regardless of the technical accuracy of those perceptions, in addition to pure scientific fact -- it is widely acknowledged that humans make behavioral decisions based on their perceptions of reality, not objective reality itself (Robbins and Judge, 2014). Though "risk" and "hazard" are often used interchangeably in the literature as well as in popular vernacular, I will define a *hazard* as the objective, quantifiable danger an object or event poses to the environment and society (Lundgren, 2013), and a *risk* as subjective perceptions of that danger, regardless of how scientifically accurate those perceptions may be (Burgess, 2015). This long-standing conflation of terminology can lead to some confusion, particularly given that seminal research (e.g., Kasperson et al. 1988) has used the word "risk" to describe both the technical, objective definition of a particular danger and its probability of causing harm to

relevant parties and the subjective social perceptions of that danger. Consequently, I used "hazard" and "risk" to differentiate between the objective and subjective, respectively.

Effective communication is crucial for mitigating and adapting to hazards. It addresses fears and concerns within communities, helping the public understand the hazard and reduce their exposure or probability of being negatively affected by it, and building trust between stakeholders and the actors responsible for remediating the hazard in question. Previous research on hazards have indicated that along with personal experience of a hazard, trust in authorities and experts has substantial impact on public risk perception (Wachinger et al, 2013). Thus, trust is an important aspect of the social amplification of risk (Mase et al, 2015). With a more thorough understanding of communications patterns surrounding risk in Great Lakes AOCs, outreach coordinators will be better prepared to address public concerns through effective channels and build further trust within AOC communities.

The social amplification of risk framework

The social amplification of risk framework was developed to address the apparent disconnect between the technical assessment of a hazard and the public responses it can generate. First proposed by Kasperson et al. in the mid-1980s to examine public reaction to nuclear incidents in the aftermath of Chernobyl and Three Mile Island, SARF was intended to explore why relatively minor risk events sometimes produced massive public outcry, and conversely, why incidents of relative severity failed to generate much public interest (Kasperson et al, 1988). Using a metaphor borrowed from electronic signal theory, Kasperson et al. suggested that risk messages pass through a number of social, cultural, institutional, and psychological "stations" in a community that amplify or attenuate public responses to a risk, and that this amplification occurs in two stages: in the transfer of information about the risk, and then in the societal response it produces. Like an electronic signal being relayed between receiving and transmitting mechanical devices like radios, risk messages may be similarly boosted, muted, or even warped as they pass from person to person within a community (Kasperson et al, 1991). Research elaborating on this original model has revealed four potential outcomes as risk messages pass through society: appropriate amplification, inappropriate amplification, appropriate attenuation, and inappropriate attenuation of a risk as public perceptions of a hazard evolve over time (Pidgeon et al, 2003). A number of suggestions have been made for how to modify the original SARF model to better capture specific concepts in the risk amplification process, such as the addition of a variable for trust or heuristics used in interviewees' cognitive processes (Mase et al, 2015). However, even three decades

since the model's development, its original form is still cited with great frequency and used to guide risk research.

A significant amount of flexibility is apparent in the varying ways the SARF has been employed since its initial development, encompassing both qualitative (Busby et al, 2009) and quantitative (Hart et al, 2011) studies and focusing on various sub-themes of the framework without necessarily covering every category that Kasperson et al. described (Kasperson et al, 1988). The creators of SARF noted that it was a descriptive rather than prescriptive model of information transfer and thus could not be falsified outright, but may simply be revealed as an ineffective model for describing a particular subject or study site (Pidgeon et al, 2003). When effectively deployed, however, SARF can provide unique insight into the complexities of interacting factors that inform the public's understanding of and reaction to a hazard that other methods of risk analysis do not adequately articulate.

Figure 1.1 below outlines Kasperson et al's original framework for describing how risk messages move through a community. A person's perception of a hazard (referred to here as "risk and risk events" in the box to the far left) is modified by a number of influences designated as "amplification stations", including how the initial existence of the hazard was communicated to them and by whom, the social groups and organizations who weigh in on the issue, the mental processes that influence how they interpret the message, and the social behaviors that may result once the hazard is recognized. "Ripple effects" refer to how risk messages and their impacts move from directly affected persons out through communities, companies, industries, technologies, and sometimes society as a whole. "Impacts" refer to the outcomes produced by a community's perception of a hazard once it passes through these amplification stations, and may include financial impacts, regulatory action, organizational changes, lawsuits, loss of confidence in local institutions, health impacts, increase or decrease in the hazard, and general community concern.

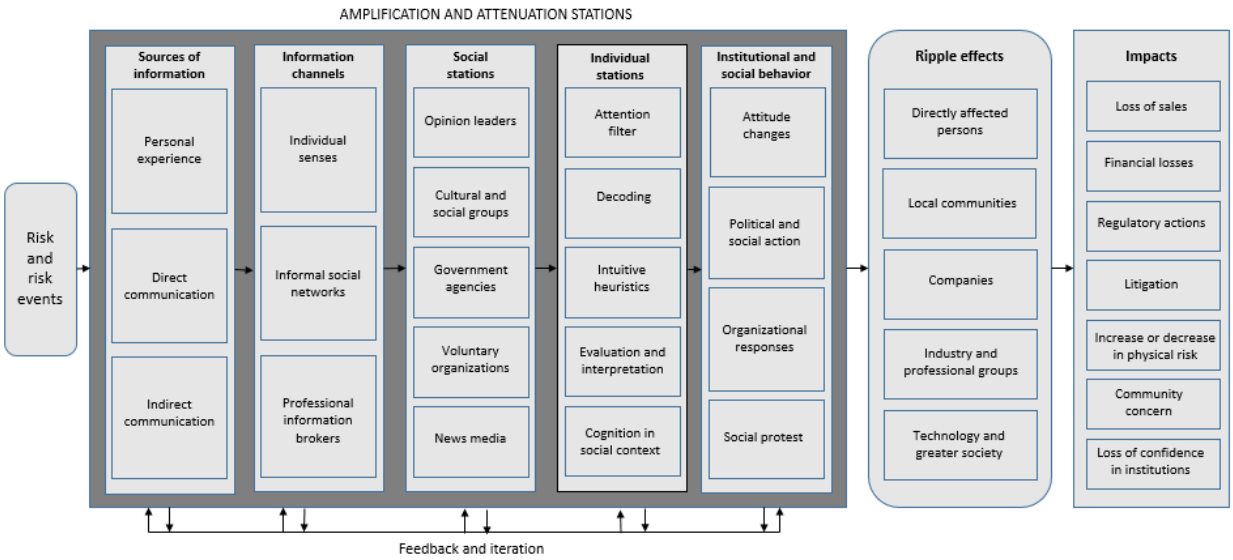


Figure 1.1: The Social Amplification of Risk Framework (based upon Kasperson et al, 1988).

Since SARF's development in the 1980s, this model and concept has been applied to a number of different natural and technological hazards, including fire suppressant chemicals (Busby et al, 2009), electromagnetic fields (Claassen et al, 2012), genetically modified foods (Frewer et al, 2002), wildlife management (Hart et al, 2011), dioxins (Park et al, 2011), wildfire (Brenkert-Smith et al, 2012), and climate change (Renn, 2011). Factors like trust, mental heuristics, media and pop culture narratives, and interpersonal interactions have all been shown to modify risk messages and subsequent human behaviors as stakeholders decide how and to what degree they are willing to interact with a given hazard or modify their behaviors in its presence (Renn, 2011). This framework has been successfully deployed in a number of different ways over the course of its development, including through both quantitative surveys and semi-structured qualitative stakeholder interviews (Brenkert-Smith et al, 2012; Renn, 2011). As of 2017, however, SARF has not been used to examine the social outcomes of legacy pollutants in Great Lakes waterways. This context would present a complex risk-related subject and provide new insights into how SARF may be successfully used to examine differences in risk perception over the course of cleanup work. As an analytical lens through which to view qualitative data collected before and after waterway remediation, the SARF model would highlight key changes in risk perception and communication over time and bring to bear perspectives that would not have otherwise been apparent through a needs assessments alone. Thus, the application of this model will benefit

environmental decision-makers as a novel tool for examining social science data about environmental cleanup work in freshwater ecosystems such as the Great Lakes.

Invisible risks

Risk perception is a process that engages the senses: while visual evidence of danger tends to be dominant, other senses like hearing or smell can inform individuals of hazards in a given environment (Parr, 2006). However, some types of risk, like the colorless, odorless concentrations of industrial pollutants bound in waterway sediment, are not perceptible through sensory information at all, and must be identified and interpreted with the help of science (Adams, 1995). Adam, Beck, and Loon (2007) characterize technologically induced risks such as pollution and climate change as largely inaccessible to the senses:

> *"They operate outside the capacity of (unaided) human perception. This im/materiality gives risks an air of unreality until the moment they materialize as symptoms. In other words, without visual presences, the hazards associated with these technologies are difficult to represent as risks."*

Public awareness of legacy industrial pollutants is made more difficult because of the environmental qualities and location of the hazard in question. Contaminated sediment in Great Lakes waterways fits all three categories of Yamashita (2009)'s definition of an invisible risk: it is "sense-hidden" because it remains out of sight below the surface of the water and the contaminants cannot be detected by the unassisted senses, it is "time-hidden" because the deleterious health effects occur due to long-term chronic exposure and are not immediately detectable, and it is "scale-hidden" because it is often difficult for stakeholders to visualize and fully understand microscopic chemical compounds or the volume of the sediment that will need to be remediated to remove it. This poses unique challenges for outreach strategies -- in some cases, the public may need to be informed that the hazard in question exists in the first place if no visual evidence of the problems it causes is readily apparent to the naked eye. Other literature on environmental contamination focuses on a separate aspect of sensory perception: smell. Studies on perceptions of contamination through odor in Areas of Concern indicates that residents who detect odors from industrial pollutants are often greatly distressed by the persistence of these industrial scents, which were once considered "the smell of money" (Jackson, 2010) but now indicate the presence of potentially dangerous pollutants (Scott, 2016). While one site in the Sea Grant Social Science Project, the former Zephyr oil refinery in The Muskegon Lake AOC, is known for emitting petrochemical odors that bother nearby residents, conditions at the other two sites are both

invisible and odor-free -- the difference scent makes to public understanding of AOC pollution, if any, will be examined over the course of this study.

While sediment contamination itself may be difficult to perceive, the process of removing it from a waterway can be highly visible to nearby communities. The dredging and capping equipment, temporary barricades, and heavy machinery involved have caused remediation work to be likened to "a construction project on the water" ("Short-Term Disruptions," 2015). The observable physical process of sediment remediation, combined with informative kiosks, digital and print media, and public meetings that explain how and why work is being performed, may bring increased public attention to this previously "invisible" environmental risk in a unique way. Because of its mildly disruptive qualities, the sediment remediation process has the potential to serve as its own form of outreach by attracting public attention to the waterways and revealing the presence of hazardous pollutants that citizens would otherwise be unable to detect. This investigation will explore these concepts in greater detail and highlight if, and to what degree, stakeholders identify the proposed process of waterway remediation as influencing their overall perceptions of waterway quality and health in this fashion.

Components of the SARF can be used to identify stakeholder descriptions of their personal experience with and sensory information about the pollution (or lack thereof) that residents have gathered at each of the three sites by analyzing the "personal experience" and "sensory information" codes. In this way, the degree of public perceptibility that contaminated sediment poses in each AOC waterway can be identified. Outreach efforts may need to be adjusted based on the sensory experiences of pollution stakeholders identify at each location -- whether common ground exists in this area between sites is a subject worthy of further analysis.

Practical elements of risk communication

Establishing best practices for risk communication is critical to the success of any environmental management process ("Communication with the Public," 2004). Among the elements of effective risk communication are identifying appropriate channels through which to share risk information, identifying factors that may complicate public understanding of the hazard in question and working to mitigate them, and directly addressing stakeholder concerns through dialogue with the community and analysis of the rhetoric used to discuss environmental problems.

While older models of risk communication proposed a unidirectional source-receiver model wherein information traveled from educated professionals to an uneducated stakeholder group, studies conducted over the past several decades have challenged this one-way model of information transfer,

suggesting instead that successful communication centers on a convergence model in which the public participates in identifying environmental issues and evaluating alternative decisions in the context of cleanup (Bradbury, 1994). The SARF works within this understanding of risk communication as an iterative process rather than a strictly linear one (Kasperson et al, 1988), a view supported specifically by reviews of the social impacts of sediment management as "non-linear system developments" (Gerrits, 2007). Recognizing and involving these diverse stakeholder groups, especially those who may have extensive local knowledge and management information but who would otherwise have limited power in the decision-making process -- has been identified as a key element in the success of sediment remediation work in the public eye (Oen et al, 2010). Thus, identifying the different actors who relay information about sediment contamination within a community -- not just environmental professionals from federal agencies, but members of municipal government, local social groups, news media, local residents, and more -- is crucial to understanding how risk messages actually develop and travel within AOCs and addressing ongoing outreach appropriately.

As previously noted, the invisible nature of much AOC pollution presents unique challenges to those looking to communicate its risks to local communities. Though the social amplification of risk framework de-centers expert knowledge and the idea of top-down information transfer, the ambiguous qualities of waterway contamination means that citizens must still largely rely on scientific experts to identify both the presence of the pollutants and their associated negative health outcomes (Jacobsen et al, 2017). To make these invisible risks more comprehensible to the public, researchers recommend science communication that focuses on making said risks visible, whether by providing maps, diagrams, and other visually-oriented educational media, or through creative interventions such as art installations that render risks more comprehensible through symbolic representation (Yamashita, 2009). Organizations like Greenpeace recognize the efficacy of providing visual evidence of large-scale invisible risks like climate change, commissioning photography projects of melting glaciers to raise public awareness of long-term, incremental, otherwise unobservable ecosystem changes (Doyle, 2007). This emphasis on providing visual evidence to bring more concrete understanding to otherwise invisible hazards could be highly beneficial in AOCs by attracting more public attention to long-standing problems that may go unnoticed in local waterways.

Rhetoric is another powerful tool in risk communication: identifying the negative impacts of pollution that stakeholders note across sites and creating a common narrative about how remediation helps remove these community problems could be a valuable strategy for environmental professionals (Tucker et al, 2008). For instance, as evidenced in other studies of environmental risk perceptions, the

economic impacts of hazards are among the most common concerns of residents of an affected area (Carlton et al, 2013), and hazards can have direct economic ramifications in impacted communities, in which even suspected but unproven environmental contamination can lower property values and reduce the chance of economic development (Jacobsen et al, 2017). The potential for redevelopment and growth oriented around water is a recurring theme throughout both news media coverage and professional environmental outreach in Great Lakes cities where waterway remediation work has successfully occurred, focusing on increased opportunities for recreation and tourism and the establishment of a new "blue economy" (White, 2015; Alexander, 2013). Learning about the shared rhetoric around industrial contaminants among different AOCs, and using this information to establish a positive counter-narrative about how remediation will address the identified problems, can generate additional community support for the projects in question (Tucker et al, 2008; Renn; 2010).

Addressing legacy pollutants in Great Lakes Areas of Concern

Sediment contamination is one of a number of hazards created by the history of industry and manufacturing in the Great Lakes. In addition to providing a nearly-unlimited supply of cooling water for factories and mills along with navigational routes for shipping supplies and products around the greater Midwest, the Great Lakes and their tributaries also provided a convenient "natural sewer" into which chemical waste products were dumped for the better part of a century -- many of which do not readily decay and instead persist for decades bound to soil particles below the surface of the water, where they continue to pose health concerns for humans and the environment ("Great Lakes Legacy Act," 2016).

Both human and environmental health are negatively impacted by the sediment-bound contaminants in AOC waterways, which is the central purpose behind cleanup efforts. Several key categories of contaminants have been identified in AOCs: polychlorinated biphenyls (PCBs), and polyaromatic hydrocarbons (PAHs), and heavy metals. PCBs, a group of chemicals once renowned for their ability to insulate and withstand heat, have been overwhelmingly shown to cause cancer in animals and negatively impact the immune, reproductive, nervous, and endocrine systems, resulting in low birth weight, childhood learning deficiencies, and thyroid problems ("Polychlorinated Biphenyls," 2016). PAHs are generated by burning petrochemical products like coal, oil, or trash, and may cause tumors, reproductive problems, skin damage, and immune system damage ("Polyaromatic Hydrocarbons," 2016). Metals including lead, cadmium, mercury, and chromium have been shown to damage the immune, reproductive, respiratory, and neurological systems and delay youth development ("Heavy

Metals," 2016). Other toxic industrial chemicals like dioxins and petroleum byproducts may also be found in aquatic sediment at some AOC sites ("About the Great Lakes Legacy Act," 2016).

The impacts of each of these contaminant groups on human and environmental health is extensively documented across a range of literature, much of which spans the late 1980s to 1990s, the era in which AOCs were first designated when the presence of said contaminants was formally identified in local waterways. Consumption of contaminated fish poses significant carcinogenic risk to anglers and their families in AOC communities (Crane, 1996), and because of the way a number of these contaminants are metabolized and stored in body tissue of both humans and wildlife, mercury and PCBs in particular are transferred through the food chain and can remain in the body long-term, where they continue to damage their host (Leatherland, 1998). Mothers can also pass contaminants on to their unborn or nursing children, disrupting prenatal and youth development, making these pollutants are a long-term public health concern (Colborn, 1993). Promoting safe fish consumption habits is thus especially important, as built-up contaminants may linger in the bodies of living fish that are then ingested by people even after the original pollution source in aquatic sediment is removed (Connelly, 1998). Because of this time delay between when contaminants are removed and when fish will become safer to eat, ongoing public outreach is an essential part of making waterways safer.

Exposure through fish consumption or direct contact with contaminated sediment not only damages human and environmental health, but has social impacts as well, changing patterns of waterway usage and generating environmental stigma in these waterway communities. One particularly relevant aspect of Kasperson et al's original paper was the call for greater exploration into the linkages between environmental risk and environmental stigma: further research is needed to define the "role of risk in creating stigma, the extent of aversion that results, and how durable such stigma become" (Kasperson et al 1988, p. 186). When a series of interviews were conducted with residents of industrial waterways in Michigan about how they experienced three aspects of stigma—affective, cognitive, and behavioral -- results indicated that although some participants were not concerned with living in a polluted community, local residents largely perceived waterway contaminants as a risk to individual health and the local environment. A number of participants feared being rejected by others and experienced embarrassment because of the stigma associated with industrial contamination (Zhuang et al, 2016).

To address these negative outcomes, a number of Great Lakes communities where sediment contamination was identified were designated Areas of Concern (AOCs). Under the direction of the International Joint Commission in the 1980s, the United States and Canada compiled a list of the 43

most environmentally damaged waterways in the Great Lakes region as Areas of Concern. AOCs are defined by the presence of beneficial use impairments (BUIs), a list of 14 potential negative influences on waterway quality such as beach closures, aesthetic degradation, illnesses in fish and wildlife, and restrictions on fish consumption ("About the Great Lakes Legacy Act," 2016). The US Environmental Protection Agency (EPA) works collaboratively with local, state, and federal partners to clean and de-list AOCs by removing BUIs to improve and preserve the health of the waterways and their surrounding human communities ("About the Great Lakes Legacy Act," 2016).

The Great Lakes Legacy Act (GLLA) is a key mechanism in the United States for addressing these concerns by facilitating cleanup projects to remove BUIs. The GLLA was designed in 2002 to accelerate the cleanup of contaminated sediment -- one of the primary causes of beneficial use impairments -- in US AOCs, and partners with federal, state, and local agencies along with private businesses to fund collaborative waterway cleanup efforts ("Project Stages," 2016). GLLA remediation strategies include several methods of removing or isolating the contaminated sediment from the rest of the waterway, including mechanically dredging the sediment from out of the riverbed and depositing caps of clean sand to sequester contaminants away from contact with open water ("Dredging," 2016). A related program, the Great Lakes Restoration Initiative, was created by federal task force to facilitate environmental restoration and protection in the Great Lakes, with a special emphasis on accelerating the cleanup of Areas of Concern ("Priorities", 2017). Together, these programs comprise the primary forces behind sediment remediation work in the Areas of Concern included in this study.

Community outreach and informational meetings are held in conjunction with AOC remediation work to inform stakeholders about the changes occurring in their local waterbody and address questions and concerns they may have. Along with the physical aspects of cleanup work, a number of outreach and communications projects are underway by local, state, and federal agencies to facilitate more stakeholder involvement in the decision-making aspects of these projects ("About the Great Lakes Legacy Act," 2016). Stakeholder involvement has been lauded as a way of democratizing environmental decision-making and facilitating public support for projects that will change some element of a community's ecological commons (Beierle and Konisky, 2001). Educational information and community meetings regarding sediment remediation have been provided by the agencies involved with AOC remediation work, which are in turn informed by a number of environmental social science initiatives. These outreach efforts are meant to improve communication and trust between community members and environmental agencies, address any concerns residents may have about the remediation work, and provide stakeholders with a better understanding of the risks of contaminated sediments and the

benefits of its removal. One of these initiatives, the Sea Grant Social Science Project, informs the core of this study and is described in greater detail below. Waterway hazards in the Great Lakes

The industrial history of the Great Lakes has produced a number of hazards that are still in the process of being addressed and remediated. In addition to providing a nearly unlimited supply of cooling water for factories and mills along with navigational routes for shipping supplies and products around the greater Midwest, the Great Lakes and their tributaries have also provided a convenient "natural sewer" into which chemical waste products were dumped for the better part of a century. Many of these contaminants do not readily decay and instead persist for decades bound to sediment particles below the surface of the water, where they continue to pose health concerns for humans and the environment ("Great Lakes Legacy Act," 2016).

Both human and environmental health are negatively impacted by the sediment-bound contaminants in AOC waterways, which is the central purpose behind cleanup efforts. Several key categories of contaminants have been identified in AOCs, including, but not limited to, heavy metals, polychlorinated biphenyls (PCBs), and polyaromatic hydrocarbons (PAHs). Heavy metals including lead, mercury, cadmium, and chromium have been shown to damage the immune, respiratory, reproductive, and neurological systems and delay youth development ("Heavy Metals," 2016). PCBs, a group of chemicals once renowned for their ability to insulate and withstand heat, have been overwhelmingly shown to cause cancer in animals and negatively impact the immune, reproductive, nervous, and endocrine systems, resulting in low birth weight, childhood learning deficiencies, and thyroid problems ("Polychlorinated Biphenyls," 2016). PAHs are generated by burning petrochemical products like coal, oil, or trash, and may cause tumors, reproductive problems, skin damage, and immune system damage ("Polyaromatic Hydrocarbons," 2016). Other toxic chemicals like dioxins and petroleum byproducts may also be found in sediment at some AOC sites ("About the Great Lakes Legacy Act," 2016).

The impacts of each of these contaminant groups on human and environmental health is extensively documented across a range of literature, much of which spans the late 1980s to 1990s, the era in which AOCs were first designated when the presence of said contaminants was formally identified in local waterways. Consumption of contaminated fish has posed significant carcinogenic risk to anglers and their families in AOC communities (Crane, 1996). Because of the way contaminants like PCB and mercury are metabolized and stored in the body tissues of fish, wildlife, and humans, the chemicals are often transferred through the food chain and can remain stored in the body long-term, where they continue to do damage to their host (Leatherland, 1998). Transgenerational effects may also occur when mothers pass contaminants onto their unborn or nursing children, disrupting prenatal and youth

development, indicating that these pollutants are a long-term public health concern (Colborn, 1993). Promoting safe fish consumption habits is thus especially important, as built-up contaminants may linger in the bodies of living fish that are then ingested by people even after the original pollution source in aquatic sediment is removed (Connelly, 1998). Because of this time delay between when contaminants are removed and when fish will become safer to eat, ongoing public outreach is an essential part of making waterways safer.

Exposure through fish consumption or direct contact with contaminated sediment not only damages human and environmental health, but also has social impacts, changing patterns of waterway usage and generating environmental stigmas in these waterway communities (Zhuang et al, 2016). One particularly relevant aspect of Kasperson et al.'s original paper was the call for greater exploration into the linkages between environmental risk and environmental stigma: further research is needed to define the "role of risk in creating stigma, the extent of aversion that results, and how durable such stigma become" (Kasperson et al 1988, p. 186). For example, a series of interviews were conducted with residents of industrial waterways in Michigan about how they experienced three aspects of stigma—affective, cognitive, and behavioral. Results indicated that although some participants were not concerned with living in a contaminated community, local residents viewed waterway contaminants as a risk to individual health and the local environment. A number of participants indicated a feeling of embarrassment and fear of being rejected by others because of the stigma associated with industrial contamination (Zhuang et al, 2016).

The Great Lakes Legacy Act and Great Lakes Restoration Initiative

In an effort to address the negative social and environmental outcomes created by legacy pollution, many of these impacted Great Lakes communities were designated Areas of Concern (AOCs). Under the direction of the International Joint Commission in the 1980s, the United States and Canada compiled a list of the 43 most environmentally damaged waterways in the Great Lakes region as Areas of Concern. AOCs are defined by the presence of beneficial use impairments (BUIs), a list of 14 potential negative influences on waterway quality such as beach closures, illnesses in fish and wildlife, aesthetic degradation, and restrictions on fish consumption ("About the Great Lakes Legacy Act," 2016). The US Environmental Protection Agency (EPA) works collaboratively with local, state, and federal partners to clean up AOCs, leading to BUI removal and ultimately AOC de-listing. This improves and preserves the health of the waterways and their surrounding human communities ("About the Great Lakes Legacy Act," 2016).

The Great Lakes Legacy Act (GLLA) is the United States' mechanism for addressing sediment contamination in AOCs by facilitating cleanup projects to remove BUIs. The GLLA was enacted in 2002 to accelerate the cleanup of contaminated sediment -- one of the primary causes of beneficial use impairments -- in US AOCs, and enables EPA to partner with, states, local agencies, NGOs, and private businesses to fund collaborative waterway cleanup efforts ("Project Stages," 2016). The GLLA program employs technologies to remove or isolate the contaminated sediment from the waterway, such as mechanically dredging the sediment from the riverbed and depositing a clean cover of sand to sequester contaminants away from contact with open water ("Dredging," 2016). A related program, the Great Lakes Restoration Initiative, was created by a multi-agency federal task force to facilitate environmental restoration and protection in the Great Lakes, with a special emphasis on accelerating the cleanup of Areas of Concern ("Priorities", 2017). Together, these programs comprise the primary forces behind sediment remediation work in the Sheboygan River Area of Concern.

Community outreach and informational meetings are held in conjunction with this AOC remediation work to inform stakeholders about the changes occurring in their local waterbody and address questions and concerns they may have. Along with the environmental aspects of cleanup work, a number of outreach and communication projects led by local, state, and federal agencies facilitate more stakeholder involvement in decision-making ("About the Great Lakes Legacy Act," 2016). Stakeholder involvement has been lauded as a way of democratizing environmental decision-making and facilitating public support for projects that will change some element of a community's ecological commons (Beierle and Konisky, 2001). Educational information and community meetings regarding sediment remediation have been provided by the agencies involved with AOC remediation work, which are in turn informed by a number of environmental social science initiatives. These outreach efforts are meant to improve communication and trust between community members and environmental agencies, address any concerns residents may have about the remediation work, and provide stakeholders with a better understanding of the risks of contaminated sediments and the benefits of its removal. One of these initiatives, the Sea Grant Social Science Project, informs the core of this study and is described in greater detail below.

Data Sources

This project performs secondary analysis on data originally collected through the Illinois-Indiana Sea Grant Social Science Project, "*Community Perceptions of Process and Benefits of Contaminated Sediment Remediation and Restoration in Areas of Concern."* The Sea Grant Social Science Project was

designed to investigate public perceptions of remediation work in AOC communities and generate needs assessments for outreach and communication. This study explores social aspects of contaminated sediment remediation in Great Lakes Areas of Concern, included stakeholder perceptions of the remediation process and the perception of benefits of remediation and outreach efforts. Project objectives were to 1) understand stakeholder knowledge of contaminated sediment in their local waterbody and the remediation and restoration process, 2) understand the impacts of contaminated sediment on society and benefits associated with remediation and restoration from stakeholders' perspectives, and 3) inform future Illinois-Indiana Sea Grant outreach efforts by documenting outreach strategies that stakeholders deem successful for engaging a wider audience within the community. This research evaluated stakeholders' connectedness to the river, use of the river, expectations about remediation, and perceived impact of contamination on a number of aspects including river recreation, sense of safety, fish consumption, and river commerce. Participants included citizens of AOC communities along with representatives from nonprofit organizations, and local, state, and federal agencies with jurisdictional and other interests in their Area of Concern (McCoy, 2013).

The original Sea Grant Social Science Project interview methodology was first developed for a pre-remediation set of interviews in Sheboygan, Wisconsin, with subsequent studies building on the techniques first established by this Sheboygan scoping exercise (McCoy, Krupa and Lower, 2014). Interviews were semi-structured and involved open-ended questions designed to encourage discussion about the waterway. Interview questions were informed by past research on waterway issues, and included general questions about interviewees' feelings and concerns about their local waterway along with specific inquiries about various characteristics such as river aesthetics, fish and wildlife health, and the waterway's effects on property values, quality of life, and the local economy, and concluded with questions regarding outreach efforts to gain a clearer understanding of how the community received information on how the cleanup will affect the river. (McCoy and Morgan, 2012). A full list of the interview questions used in the original studies is provided in Appendix C. Initial lists of potential interviewees were developed from recommendations by AOC outreach teams in the area (McCoy and Anderson, 2014), by recruiting participants from lists of public meeting attendees (McCoy, Krupa and Lower, 2014), and by snowball sampling (McCoy and Morgan, 2012), where interviewees recommended other local residents who possessed characteristics of interest to the study. Participants at each site included city officials, representatives of government agencies, local business owners, boaters, recreationalists, residents, and members of local environmental groups, among others. Sampling continued until saturation indicated by repetition of themes was reached (Nigrelli and Norris, 2015).

Each interview lasted approximately 30 to 60 minutes, depending on how long the interviewees chose to speak, and was audio-recorded with participants' permission. Researchers took notes on the main themes that emerged during each interview and promptly transcribed the audio recordings once interviews concluded (McCoy and Morgan, 2012).

Researchers used six out of nine methodological strategies described by Guba and Lincoln to achieve qualitative rigor (1982, 1989). *Adequate* reference materials were studied prior to the interviews, methodological organization was established a priori to allow for *audit trailing*, and *negative case analysis* helped avoid researcher bias by editing and reorganizing codes to analyze outliers within the data. Researchers conducted data analysis separately at first and then used *peer debriefing* to confirm themes together. *Participant confirmation* was used via email exchanges to credit the study findings as accurate and representative, and by participating in informal activities within the community and establishing trust and rapport with interviewees, researchers were able to *achieve prolonged engagement* (Nigrelli and Norris, 2015).

Project Aims and Contributions

This thesis provides important contributions to the literature on the social amplification of risk framework, which has never been applied to the issue of industrial waterway pollutants or Great Lakes restoration work, as well as to the larger body of Great Lakes social science research in general. It also builds on the body of work surrounding the social components of sediment management as well as that on communicating invisible risks, both of which have been identified as concepts in need of further exploration and research (Gerrits, 2007; Yamashita, 2009). From an applied perspective, it extends the utility of site-specific needs assessments by engaging in novel comparative analyses over time and across geographic locations. Together, these chapters should demonstrate the utility of the SARF as a method of examining the social construction of environmental risk and how it is communicated, and will then use the framework to test the potential of formulating a general set of best practices for outreach about AOC remediation work.

CHAPTER 2: EXAMINING THE SOCIAL AMPLIFICATION OF RISK IN THE SHEBOYGAN RIVER AREA OF CONCERN

Introduction

Problem statement

Among the many issues facing freshwater resources around the globe, sediment-bound pollutants from a legacy of industrial processes represent one of the most long-lasting threats to ecological and human communities. Substances like polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), and heavy metals often persist in waterways long after the industries that released them into the environment have departed. These contaminants have caused substantial impairments and warranted removal efforts in freshwater ecosystems worldwide (Comby et al, 2014; Oen et al, 2010). In the Great Lakes region of the United States, a number of waterways with a history of industrial pollution have been designated as Areas of Concern (AOCs), and many of these are targeted for sediment remediation. While sediment remediation work has reduced physical, chemical, and biological hazards that pollutants pose to human and environmental health, risk perception of the contaminants and cleanup process -- and the social impacts thereof -- is less straightforward. Remediation projects proposed in these AOC communities have been met with a blend of enthusiasm and concern from local residents, who have sometimes expressed ambivalence toward what might otherwise be seen as a clear environmental improvement. A greater understanding of how information shapes risk perceptions and the channels through which stakeholders receive information about hazards in their waterways will provide valuable insight into these varied interpretations of remediation efforts.

Public understanding of hazards and risks is an important aspect of environmental communication (Bradbury, 1994). While a hazard is defined as a discrete, concrete object or event capable of causing harm to humans or the environment (Lundgren, 2013), risk is a more complex phenomenon: it is largely influenced by social processes surrounding the perceived likelihood that a hazard will generate negative impacts on individuals or communities (Burgess, 2015). Many studies have noted that perceived risks sometimes have very little to do with hazards. For example, relatively safe but novel technologies like nuclear power or genetically modified foods are often interpreted as high-risk by the public and responded to with protest and outrage, whereas common but often deadly events like car crashes or exposure to secondhand smoke are seen as relatively low-risk despite the frequency and severity of their occurrence (Kasperson et al, 1988). Community responses to AOC waterway

contamination and remediation is similarly complex and at times contradictory. Some stakeholders view legacy pollutants as a severe health risk that prevents their enjoyment of local waterways while others instead view the cleanup process itself as an unnecessary threat that will "stir up old sins" rather than improve environmental conditions (McCoy et al, 2014). The social amplification of risk framework (SARF) explains how risk messages associated with waterway contamination produce these varied stakeholder responses at different stages of the remediation process. Specifically, hazards like sediment contamination interact with psychological, social, institutional, and cultural processes in ways that may amplify or attenuate public responses to a perceived risk (Kasperson et al, 1988). The SARF has been applied to a diverse range of natural and technological hazards since its development in the 1980s. However, no studies have applied SARF to better understand sediment remediation despite the insight it could provide on risk perception and communication.

This paper addresses the central question: ***To what extent does the social amplification of risk framework provide an adequate basis for examining changes in risk perceptions and communication as a result of sediment remediation?*** In response to this question, I drew on stakeholder interview data collected in Sheboygan, Wisconsin, before and after an extensive sediment remediation project carried out from 2012 to 2013 to determine how public perceptions of risk were amplified or attenuated, and examine how local actors and communications channels cited by interviewees changed over the course of a cleanup project. My analysis of communications channels illustrated ways perceptions of risk changed at the community level once the hazard of sediment contamination was removed. Results generated from my investigation of risk amplification before and after concerted hazard reduction activities demonstrated how social and institutional factors interacted with physical, chemical, and biological changes to the waterway. My results also offered guidance on how to modify public understanding of local waterway issues and identify changes in the social amplification of risk within the same community over time.

Methodology

Using the social amplification of risk framework (SARF) as a lens for examining changes in risk perceptions as a result of sediment contamination remediation, I analyzed data from interviews conducted through the Sea Grant Social Science Project in Sheboygan, Wisconsin, before and after an extensive sediment removal project. The area had been designated as an AOC due to a high level of impairment created by legacy industrial and urban pollutants ("Sheboygan River Legacy Act Cleanup," 2016). Remediation activity began in 2012 and was completed June 2013. Using a qualitative coding

scheme derived from stakeholder interviews conducted before and after remediation, I tested the following hypotheses:

H1: Codes related to the SARF model will capture the important elements of risk perception and communication.
H2: Public perception of waterway risk will differ before and after remediation.
H3: Communication surrounding waterway risk will differ before and after remediation.

By analyzing the communication channels that were used before and after sediment remediation work and their frequency of use, I illustrated the ways perceptions of risk changed at the community level once the hazard of sediment contamination was removed.

Study site: Sheboygan, Wisconsin

The Sheboygan River AOC is located approximately 60 miles north of Milwaukee, Wisconsin, and extends 14 miles from Sheboygan Falls through the city of Sheboygan into Lake Michigan ("Sheboygan River Legacy Act Cleanup," 2016). The original Sea Grant needs assessment (McCoy and Morgan, 2012) identified a strong local identity based around Lake Michigan and the Sheboygan River, which the community depends on for commercial purposes. The Sheboygan River is lined with businesses such as restaurants, bait shops, and hotels. Public parks, boat clubs, and a running trail are also located along the river. Commercial fishing vessels are also housed along the river and fishing is a popular activity (McCoy and Morgan, 2012). Due to historic industrial activity along the waterway, sediment in the river was contaminated with PAHs and PCBs, and nine out of fourteen BUIs are present in the waterway, including impairments to fish and wildlife, restrictions on fish consumption, and impaired use of the local harbor due to dredging restrictions. As a priority AOC targeted for short-term delisting by EPA, a combination of federal, state, and local partners secured approximately $85 million in project funding to work towards delisting the AOC ("Sheboygan River Legacy Act Cleanup," 2016). In 2012, EPA began a Legacy Act project to remove 160,000 cubic yards of aquatic sediment contaminated with PCBs and PAHs. Simultaneous sediment remediation was performed in the Sheboygan River as well as in the harbor under GLRI, and Superfund remediation work was completed on the Sheboygan River in 2011. Researchers noted that residents likely perceived these separate projects as one big project, which environmental social scientists framed their communications around accordingly (McCoy, 2013). The cleanup was completed in June 2013, though removal of remaining BUIs remains an ongoing process ("Restoring Sheboygan River AOC," 2016).

Fig 2.1: Sediment Remediation Work in the Sheboygan River Area of Concern

Data sources

This investigation is based on secondary analysis of existing interview data collected through the Sea Grant Social Science Project to investigate public perceptions of remediation work in Sheboygan and generate needs assessments for outreach and communication. Semi-structured interviews were conducted with representatives of stakeholder groups directly affected by the remediation (see Appendix C for interview questions). This included local residents as well as representatives of state and local governmental organizations, NGOs, and local businesses (McCoy 2013). Interviews generally lasted 30 minutes to an hour and were conducted in person or by phone and recorded with the permission of the participants (McCoy, 2013). The resulting audio recordings were transcribed.

For the purposes of this secondary analysis, a sample of 10 interviews was determined to be both necessary and sufficient to provide an ample range and saturation of stakeholder types and opinions while remaining feasible for the scope of this project from a data management perspective (Saldaña, 2013). This included 10 of 11 pre-remediation interviews conducted in 2012 and 10 of 20 post-remediation interviews conducted in 2013. To control for sampling bias, a list randomizer was used to shuffle the order of the interviews initially collected through the Sea Grant Social Science Project, which were carefully read in their new order to search for substantial responses to both of the following interview questions:

- *"What do you see as the biggest problems or threats facing the waterway?"*
- *"What is the best way for the community to be informed about cleanup and restoration work?"*

If interviewees provided clear, direct answers to both of these questions, the interview was used as part of the sample. If one or both questions were not answered by the interviewee, the interview was rejected and the next one down the list was examined for evidence instead until a sample of 10 was collected.

Data processing and analysis

To analyze the stakeholder interview data for this investigation, the categories identified by the original SARF model were used to develop an initial coding scheme, which was applied to the interview transcripts using the qualitative data analysis program Atlas.ti (Friese, 2012). This theory-driven approach involved three steps: 1) generating the initial codes based on the components of SARF (with an omnibus "other" code to capture elements of risk perception and communication not captured by SARF), 2) reviewing and revising the codes in the context of the interview data, and 3) determining the reliability of the codes (Decuir-Gunby et al, 2011). The codebook was repeatedly refined over the course of analysis, with iterative changes to definitions and codes recorded to ensure the validity of results (Creswell, 2012).

When developing a coding strategy for this project, the language used in Kasperson et al's original framework was updated for clarity in a few instances -- the initial "risk and risk events" box was changed to "hazard: legacy industrial pollutants," and "increase or decrease in physical risk" was changed to "hazard exposure" in the impacts category. "Attitude change" was changed to "opinion and behavior changes" based on usage of the term attitude in more modern environmental psychology literature. In addition, language in the "impacts" category was modified slightly to reflect that loss might not be the only potential outcome of risk perception -- "loss of sales" was modified to "changes in sales," "financial losses" was changed to "financial consequences," and "loss of confidence in institutions" was changed to "confidence in institutions." These minor alterations are not intended to alter the model's categories in any meaningful way, but are meant to facilitate greater clarity in discussion through more precise wording.

The "before cleanup" and "after cleanup" models were compared with one another to determine not only how risk messages changed in response to the hazard of contaminated sediment decreasing by its removal from a waterway, but how the influence or relevance of different amplification stations within the same community changed over the progression of a cleanup project.

Visualizations inspired by Kasperson's original SARF model were generated to illustrate code frequency in each predefined category. Color gradients were assigned to a range of values based on the frequency of responses in each category, with darker values indicating a greater number of quotations in a given category. Table A.1 in Appendix A lays out the frequency of responses in each code category before and after remediation.

Results

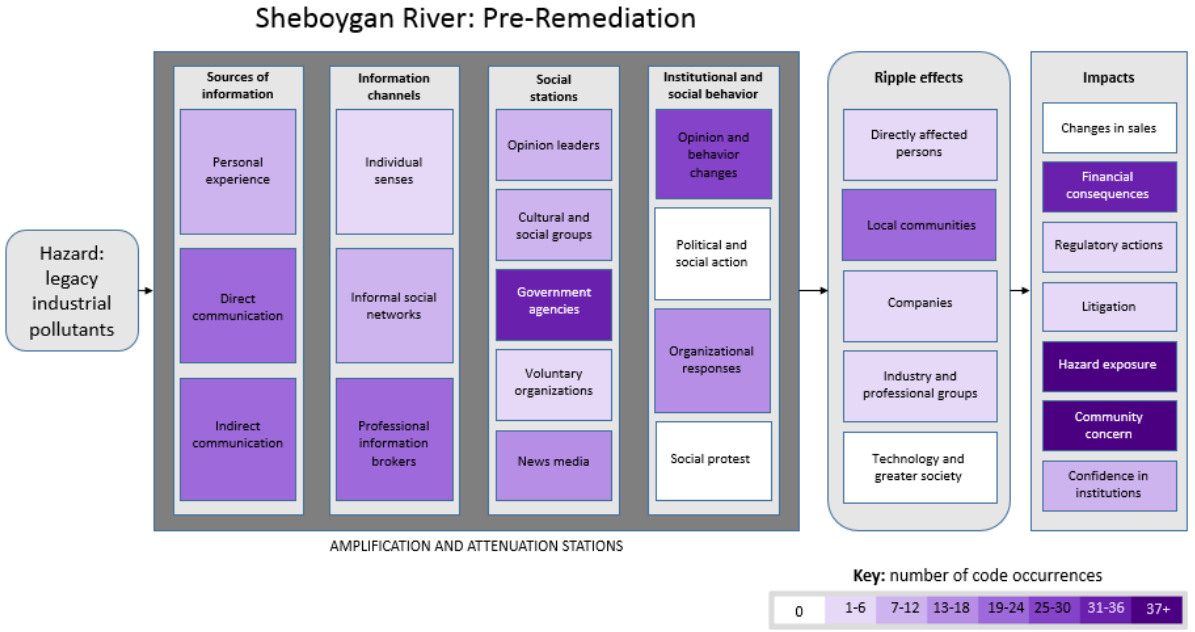
In total, there were 442 coded statements across 111 pages of transcription in the pre-remediation interviews. This interview sample spanned a relatively diverse range of Sheboygan residents, including municipal officials, business owners, academics, members of NGOs, and local citizens. There were 335 coded statements across 53 pages of transcription in the post-remediation interviews. Like the first set of interviews, a relatively diverse group of stakeholders were included in this sample, including members of local governance, professional fishermen, riparian property owners, and environmental educators. Three of the same interviewees (1E, 3E, and 7E) had previously participated in the first round of interviews, though direct comparisons between their responses before and after remediation was beyond the scope of this study.

H1: The results of coding demonstrate the the SARF model captures important elements of risk perception and communication.

Interview data from the Sea Grant Social Science Project was successfully mapped onto almost every aspect of the original model, demonstrating SARF's utility as a lens for secondary data analysis. The SARF provided a helpful roadmap for understanding the social amplification of risk in Sheboygan, with the physical shape of the model demonstrating an effective way to organize information. One would not be able to identify the significant changes pre- and post-remediation based only on the visualizations in Figure 1.2 below, but developing and analyzing the content captured by sub-codes told a compelling story of the changes instituted by waterway cleanup work. The major differences between pre- and post-remediation occurred on the sub-code level. A quantitative tally of frequencies of code occurrence alone did not tell the whole story. While SARF was a useful way to frame and organize the interview data used in this project, qualitative analysis and discussion of findings within each category was crucial for understanding their meaning. Decontextualized code frequency counts across the original SARF categories did not adequately illustrate the differences in pre-and post-remediation risk perception and communication. However, examining sub-codes revealed rich insight into the nature and

efficacy of the organizations and processes within each “amplification station,” and the SARF provided a coherent structure for organizing and analyzing this semi-structured interview data in a novel way.

Plugging both pre- and post-remediation interview responses into the SARF model revealed that professional information brokers in the form of government agencies were the most commonly cited social stations in the transfer of risk messages, followed by news media. Indirect communication sources, such as newspaper articles, mailbox flyers, and riverside signage were most frequently referenced by interviewees, followed closely by direct communication between stakeholder groups. These risk messages produced changes in public and behavior around the waterway and some organizational responses from local agencies, which were felt as community-level effects. Hazard exposure, community concern, and financial consequences were the impacts most frequently discussed by interviewees both before and after cleanup. However, while these results appeared congruent on the categorical level before and after remediation, analysis within each category revealed differences in which specific actors and factors were most frequently cited at different stages of the cleanup process, as well as illustrated a dramatic change in the public perception of waterway risk. Figure 2.2 below provides further information on the frequency of specific responses.



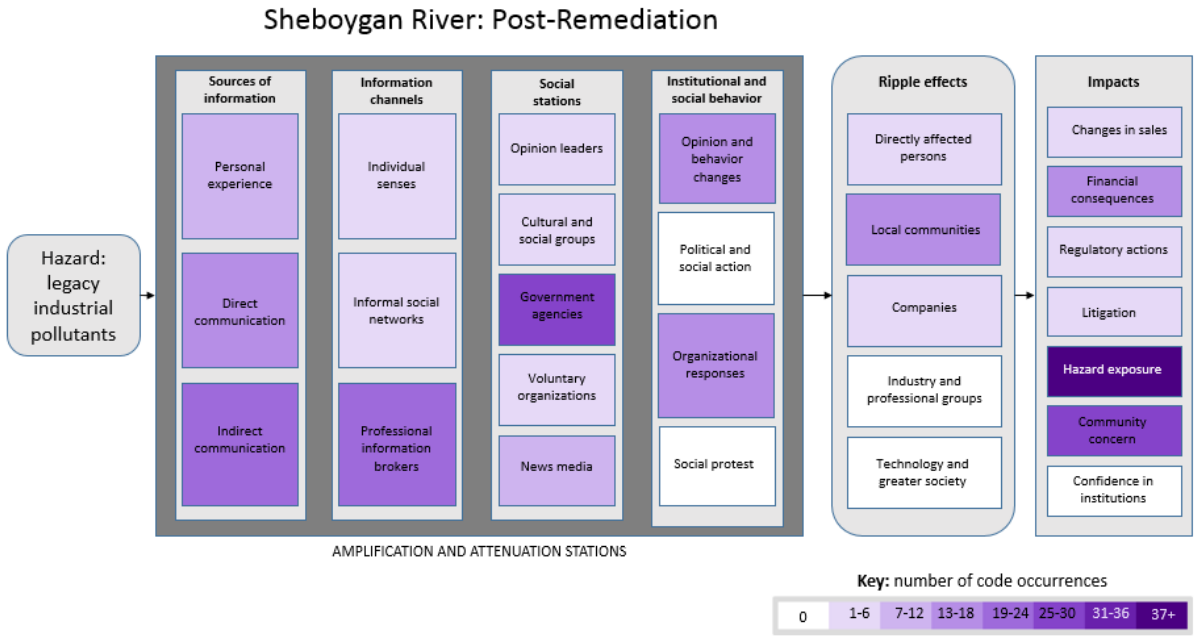


Figure 2.2: Pre-Remediation and Post-Remediation SARF Models

H2: Public perception of waterway risk differed before and after remediation.

The perception of risk was greatly attenuated across all impact categories post-remediation. In both the pre- and post-remediation studies, exposure to the hazard of the legacy industrial pollutants was the most discussed issue in the "impacts" category (40 pre-remediation, 38 post-remediation), followed closely by community concern (39 pre-remediation, 27 post-remediation) and then financial consequences (31 pre-remediation, 16 post-remediation). Pre-remediation interviews indicated risk amplified in each of these categories in the first set of interviews, and all attenuated post-remediation, but these categories remained the most frequently discussed over time. Table 2.1 displays the differences in risk perception pre-and post-remediation below.

Table 2.1

Risk Perception Pre- and Post-Remediation

	Amplified Risk		Attenuated Risk		Null Risk	
Impact Code	Pre-remediation	Post-remediation	Pre-remediation	Post-remediation	Pre-remediation	Post-remediation
Community concern	16	1	12	19	3	7
Finance	14	0	0	13	7	1
Hazard exposure	29	2	3	29	2	7
Institutional confidence	3	0	0	0	0	0
Legal action	1	0	0	1	0	0
Regulation	2	0	0	1	0	0
Sales	0	0	0	0	0	3

Interviewees' language provided distinct examples of changes in risk perception over the course of the project. Before remediation, stakeholders described the Sheboygan River as "dirty", "polluted", and "contaminated" (1D, 3D, 4D), talked about "three-eyed" and "glow in the dark" fish (1D, 2D), and water that was "dangerous" (7D) and akin to "falling in lava" (3D). Post-remediation, interviewees talked about the river as being "cleaner" (2E, 5E, 7E, 10E), "safer" (2E, 7E), "healthier" (3E, 4E, 9E), and "really beautiful" (9E), as well as "great that there's an area of the remediation that you can actually watch" (5E).

> *"And when you talk to people, even the people that I used to kayak with that were like "don't touch the water, your hands are gonna glow!" and it was like "don't put your feet in there" and that whole perception is slowly leaving... The one person, we go with a friend, she said, "it's so nice to be able to, you know, there's enough depth and to just feel the sense of security's back, that you're not at risk by having your kayak in the water and touch[ing] the water." (Interviewee 8E)*

Public perception of the stigma generated by the contamination, and how it may or may not be fully removed post-remediation, was somewhat mixed in interviewee statements. "...That stigma is gonna be gone and people are going to be drawn to those particular properties," said interviewee 3E, reflecting the optimistic attitude that many stakeholders had towards the potential opportunities for redevelopment along the waterways. Others were somewhat more reserved in their predictions: "...because that stigma's been there for so long, it may take a generation before that's gone," said interviewee 9D.

While risks were largely attenuated by the removal of the hazard, overall awareness and discussion of impact categories did not decline after remediation was complete, but simply shifted to a more positive outlook on the safety and health of the Sheboygan River. However, the pre-remediation interviews were generally longer and generated more codes than the post-remediation responses. Although the interview questions were largely congruent, pre-remediation interviewees spent a significant amount of time discussing both their current perceptions of waterway health as well as their hopes and fears for the future of the river, leading to longer responses on average than post-remediation interviewees who mainly discussed the river in its current, improved condition and fewer speculations on its future. This was largely due to the original Sea Grant Social Science Project design, which asked participants to describe aspects of the river as it was as well as how it might change after cleanup in pre-remediation interviews, but focused exclusively on current aspects of the river in post-remediation interviews, which decreased the length of responses.

H3: Communication surrounding waterway risk differed before and after remediation.

Risk communication changed before and after remediation on a granular level. While individual actors varied before and after cleanup, the proportion of codes in each SARF-designated category stayed largely stable. Government agencies continued to be the most popular sources of information in the "social stations" category, cited 36 times pre-remediation and 26 times post-remediation. News media was cited as the second most popular social station and a key source of indirect communication, mentioned 16 times pre-remediation and 12 post-remediation.

I anticipated that if communication surrounding waterway risk had changed before and after remediation, these differences would be revealed in quantity and source through both direct and indirect communication. I found that while the overall type and quantity of information as defined by the SARF model did not change, the subcategories within each category did shift. Though code categories stayed mostly congruent between interview sets, the specific actors involved *did* change over

the course of the remediation work. Specifically, while government agencies were the most cited social station categorically, for instance, the individual actors seemed to vary pre-and post-remediation. Pre-remediation, EPA was the most often-mentioned entity with 14 codes attributed to the agency, followed by DNR (9), the Army Corps of Engineers (6), and others. Post-remediation, however, University of Wisconsin-Extension became the most often cited social station, and was mentioned in 10 codes, followed by dredging contractors (5), DNR (4), EPA (4), and then others. Indeed, over the course of remediation, the role of EPA and other federal agencies seemed to be backgrounded to more locally embedded sources. This finding highlights the need for agencies to share information with one another to effectively communicate risk to the public, as their individual roles as professional information brokers may wax and wane within the community over the course of a cleanup project. Detailed results are provided in Table 2.2 below.

Table 2.2
Social Stations Pre- and Post-Remediation

	Pre-Remediation Interviews		Post-Remediation Interviews	
Social Amplification Station	**Number of times cited**	**Name**	**Number of times cited**	**Name**
Government agencies	36	EPA (14), DNR (9), Army Corps of Engineers (6), local government (2), FDA (2), NOAA (1), Wisconsin Sea Grant (1), Great Lakes Fishery Commission (1)	26	UW-Extension (10), "dredgers" (5), DNR (4), EPA (4), unspecified federal government (2), local government (1)
Voluntary organizations	2	Sheboygan County Conservation Association (2)	2	Sheboygan Basin Partnership (1), Parks Board (1)
Social groups	10	Camp Y-Koda (2), boat clubs (7), business community (1),	2	Boaters (1), yacht clubs (1)
Opinion leaders	9	Self-cited [1D, 5D, 6D, 8] (4), boat club owners (2), mayor (2), personal contacts (4)	6	Self-cited (4), UW-Extension coordinator (2), personal contacts (2)
News media	16	Local newspapers (8), city website (2), local TV broadcasting (2), local radio (1), social media (2), unspecified "news media" (1)	12	Local newspapers (5), social media (2), local TV broadcasting (1), local radio (1), unspecified "news media" (3)

A blend of direct and indirect communication strategies were seen as effective both before and after remediation: direct was cited 21 times pre-remediation and 18 post-, and indirect cited 24 times pre- and 19 post-remediation. Indirect communication was cited with slightly more frequency both pre-

and post-remediation, but also saw granular changes in subcategories of communication sources. Pre-remediation, interviewees most commonly cited local newspapers as a way they had heard about the impending cleanup project or an effective channel through which to spread information within the community as the project progressed, producing eight separate codes. Fish advisory signage was the second most common indirect communication source, with five stakeholders discussing the warning signs posted along the river meant to alert the public to the presence of contamination. Printed newsletters from various agencies involved in the cleanup work and information posted on local and state government websites also provided information to stakeholders before the cleanup began. After remediation was complete, seven stakeholders cited mailbox flyers and newsletters from the groups involved with the remediation as key sources of information they had received during the cleanup process. Newspaper articles about the cleanup were mentioned five times, and cleanup-related signage that highlighted what improvements had been made to the waterway joined the fish advisory signs. Results are detailed in Table 2.3 below.

Table 2.3
Indirect Communication Sources Pre- and Post-Remediation

Indirect communication source	Number of times cited pre-remediation	Number of times cited post-remediation
Local papers	8	5
Print newsletters/flyers	4	7
Government websites	4	0
Fish advisory signage	5	2
Cleanup-related signage	0	3
Public TV broadcasting	2	1
Radio broadcasting	1	1
Totals	24	19

I found that numerical frequency counts alone did not tell the full story of public opinion on the efficacy of each of communication source or strategy. Interviewee responses to news media were one of the key areas where an information source or social station was mentioned frequently, but not always in a positive light. When asked about the best way to communicate with the public about the clean-up work and where they and their fellow community members might have received information about remediation in the past, a number of stakeholders brought up local newspapers as a way to transmit information -- but many followed up on their suggestion with a warning that newspaper subscriptions in Sheboygan had declined dramatically in recent years and that the relevance of printed papers was decreasing, as well as with skepticism over the quality of local reporting. Likewise, the cleanup-related

signage and informational kiosks along the boardwalk produced by UW-Extension were the subject of high praise and seen as a very valuable outreach tool, despite being mentioned only three times.

The process of waterway remediation interceded in communication by allowing different players within a given community to emerge as federal leadership subsides and leadership transfers to more local players in order to sustain effort. This transition in both social stations and the communication sources they deployed to educate the public over the course of remediation highlighted the necessity of multiple forms of outreach from multiple actors within the community, rather than identifying one specific, consistently dominant information source that served as the primary amplifier of risk messages within the AOC over time.

Discussion

Application of the social amplification of risk framework

The SARF framework was a useful analytical tool for secondary analysis of interview data that explored waterway cleanup work. SARF's most notable strength was capturing which methods of communication, promoted by which informational sources, have the greatest utility within a target community. This framework provided a story at a glance -- I saw the relative importance of various actors and factors through which people's risk perception was influenced by their saturation in the chart. This informed a coherent narrative and guided the development of outreach strategies. In this case, the primary sources of information both before and after Sheboygan's waterway remediation work came from professional information brokers who worked at government agencies, supplemented by local news media. A blend of indirect and direct communication strategies were used to engage with the public about the issue, inspiring organizational responses from the actors involved with the cleanup work and changes in the public's attitude towards the waterway in question. Application of the SARF also revealed that stakeholders mostly saw the impacts of the pollution affecting them on a community-scale level, with the main impacts including their exposure to the hazard, community concern about the issue, and financial consequences due to stigma surrounding the waterway.

The transfer of risk information in Sheboygan followed a number of pathways highlighted in the social amplification of risk framework. While professional information brokers, mostly in the form of government agencies, are the primary information channels and social stations in Sheboygan, informal social networks such as cultural and social groups, as well as opinion leaders were instrumental in generating horizontal information transfer both before and after remediation. This finding aligns with past research conducted by Brenkert-Smith et al (2012) that demonstrated how risk information about

wildfires was spread vertically (from professional information brokers to residents) and horizontally (from one neighbor to another), thereby suggesting that the communication process was nonlinear. All stakeholder types within this interview set cited experts affiliated with agencies involved in the cleanup work as key sources of their information about both waterway hazards and the cleanup work.

Public confidence and trust in various professional actors involved with a hazard management response was an important factor in the social amplification of risk (Mase et al, 2015), and the results of the Sheboygan interviews indicated that trust in agencies involved with the cleanup was not affected by the passage of time. The collection of data before, during, and after a rise in UK media coverage of GMOs has demonstrated that public perceptions of risk increased and decreased in line with the SARF model, and that in this case trust in public institutions charged with protecting the public was not affected (Frewer et al, 2002). Findings from the Sea Grant Social Science Project were largely congruent with the exception of one interviewee in pre-remediation interviews, who was frustrated with the EPA and other regulatory agencies for taking such a long time to get the cleanup work underway. Post-remediation, however, no stakeholders expressed distrust or dissatisfaction with government agencies or the professional information brokers representing them. No actors within any social station attempted to interrupt or actively reduce public perception of risk in Sheboygan, unlike the corporate efforts observed in Busby et al (2009) in response to controversy over a hazardous fire suppression chemical.

The accuracy of information disseminated over the course of the project was trusted to varying degrees. Participants were particularly critical of local newspaper coverage of the remediation process, citing information as inconsistent, sporadic, and of dubious quality. Claassen et al. suggested that newspaper coverage of hazards -- in their study, electromagnetic radiation -- often misses much of the nuance of scientific perspectives on a hazard and presents “a layman’s perspective of risk” (Claassen et al, 2012). Sheboygan residents indicated a lack of confidence in the reporting quality of their local papers and tended to go directly to professional information brokers through government agencies instead to get information on the waterway contamination and cleanup process. Mase et al (2015) highlights historic SARF studies that that “point out a disproportionate research emphasis on the role of mass media compared to interpersonal communication in the amplification/attenuation of risk in society. Informal interpersonal interactions have the potential to significantly influence the amplification processes. ” Indeed, news media came in far behind government agencies as a relevant social station in Sheboygan, and direct communication -- conversations with professional information brokers as well as with fellow stakeholders about the project -- generated almost as many codes as indirect

communication both before and after remediation. These findings bolstered Mase et al's assertions that interpersonal communication plays a critical role in risk communication, and in the case of Sheboygan, may be even more important than the role of news media as a social station.

Community perceptions of waterway risk

Discussion of environmental stigma occurred regularly in both sets of Sheboygan interviews, producing responses very similar to that of a set of interviews conducted with residents of dioxin-contaminated industrial waterways in Michigan in 2016 by Zhuang et al. Results of this study indicated that although some participants were not concerned with living in a contaminated community, local residents largely perceived dioxin as a risk to individual health and the local environment, with several participants indicated a feeling of embarrassment and fear because of the stigma associated with industrial contamination. Instead of actively seeking information about dioxin contamination and remediation, participants often relied on information provided to them by government officials, and interviewees avoided eating locally caught fish and prepared fish more carefully in order to avoid exposure to contaminants (Zhuang et al, 2016). This is highly congruent with the findings from this study -- strong negative feelings towards waterway contamination were expressed pre-remediation, avoidance of the waterway and of fish consumption was noted, and government officials were also the primary source of pollution information in the greater Sheboygan area.

While most stakeholders identified sediment pollutants as a serious issue that consequently increased their perception of risk surrounding interaction with the Sheboygan River, risk attenuation was noted in some stakeholders pre-remediation in their discussion of other community members who did not see sediment contamination as a serious concern. Fishing and interaction with the waterways persisted even when the pollutants were identified through signage and other readily accessible public outreach efforts, leading to increased exposure to the hazard among certain community members. This was similar to the "optimism bias" displayed in past research whereby interviewees did not see themselves as susceptible to issues from low-dose, long-term exposure to contaminants and saw other, more acute and readily "visible" forms of contamination, like air pollution, as a greater risk than lead exposure (Harclerode et al, 2016). Studies of risk perception have identified an apparent paradox that indicates a weak or null correlation between perception of risk and appropriate protective actions towards a given hazard. That is, individuals either understand the risk but decide the benefits of interacting with the hazard in question outweigh the cost, understand the risk but do not recognize the personal agency they must take in avoiding the hazard through their own actions, or understand the risk

but have little ability or agency to change the circumstances surrounding their exposure to the hazard (Wachinger et al, 2013). Examples of fishermen who ate their catch despite consumption advisories because their enjoyment outweighed their concern, those who did not follow the recommended preparation guides, and those who relied on fish as a subsistence food resource were identified by interviewees, illustrating that a risk perception paradox may be occurring in Sheboygan. These factors should all be considered when designing future outreach material -- though many of the risks posed by sediment contamination have been removed by the cleanup work, persistent chemicals in the local fish populations and lingering environmental stigma may still need to be addressed for years to come.

Limitations and future research

Most limitations in the SARF framework's initial utility in this project stemmed from the limitations of secondary analysis rather than inherent insufficiencies of the framework. Almost all of Kasperson et al's original categories were used as initial codes, with the following exceptions: the "individual amplification stations" category, which included "attention filters, decoding, intuitive heuristics, evaluation and interpretation, and cognition in social context" (Kasperson et al, 1988). The Sea Grant Social Science Project interviews did not address the cognitive processes that would inform each of these sub-categories in the minds of individual stakeholders, and any attempt at filling out these categories would be based on conjecture, so "individual amplification stations" was rejected as a useful category of codes in the context of this project. In addition to the remaining code families from Kasperson et al's original model, a code category for "change in risk message" was added to indicate whether stakeholders perceived an increase, decrease, or no apparent change in the risk messages they received from each amplification station.

A few key updates to the framework would make SARF more effective as a modern tool for analysis, as reflected in an "other" code that was used to track important information that was not easily incorporated in the original model. "Social media" and "academia" emerged as potential new codes in the social stations family that may be relevant to include in updated versions of the SARF. The inclusion of digital media and social networking, mentioned specifically in three codes in this analysis would be helpful forms of indirect communication and academia should be considered an additional social station. The influence of the Internet, and social media in particular, were not explained by the SARF model originally developed in the 80s, but this was an undeniable aspect of how information spread in the context of this research. Quotes referencing social media were included in the "indirect

communication" and "informal social networks" categories, but an addition of a category specifically for social media would enhance the broader "information channels" station.

Academia occupied a similarly ambiguous position in this model: depending on circumstances or funding sources, a professor of environmental science might be classified as an opinion leader, part of a voluntary organization, or part of a government agency. Sea Grant and Extension, which were mentioned in nine codes, filled a uniquely liminal position within this coding scheme. Academia and extension were not included in Kasperson's original model, and deciding where to place these important players was difficult, as they are neither truly governmental nor voluntary groups/NGOs. I ultimately decided to categorize them as "government agencies" within the context of the original framework due to the nature of their work and their governance partnerships -- Sea Grant programs in particular are a national network administrated and supported by NOAA, though implemented in each coastal state through universities ("Who We Are," 2017). My working categorization of Sea Grant and Extension is not a perfect fit -- in fact, conflation of Sea Grant with EPA and other government agencies was a source of ongoing consternation for the original researchers who developed the original Sea Grant Social Science Project -- but to my estimation was the best place for them in a model as close to Kasperson's original framework as I could manage. An updated framework would specifically include a new social station category for "academia," under which Sea Grant, other university Extension programs, and other university-based research would be placed.

Future studies based on the SARF could examine the utility of various updates to the model, particularly those addressing the digital transfer of risk information through websites and social media. Other areas for further research could involve a longitudinal study of individual stakeholder perceptions over the course of a cleanup project, basing a survey on SARF-specific code categories rather than reverse engineering them out of secondary data so as to include individual cognitive processes. Alternately, future research could draw from additional research in the context of the Sheboygan River to determine whether stakeholder understandings of impacts, like improved public opinion of the waterway and redevelopment opportunities, manifest in the years following the dredging work.

Conclusion

Despite the occasional ambivalence and uncertainty stakeholders expressed about the efficacy of waterway remediation in Sheboygan and in other AOC communities prior to cleanup work (McCoy et al, 2014), public perceptions of waterway risk decrease significantly in parallel to the removal of the pollution hazard on the Sheboygan River. Though most participants in the post-remediation interviews

state that the river had not experienced an obvious aesthetic change from the dredging work, they nonetheless indicate greater feelings of safety, security, and comfort interacting with the river after cleanup was complete, and are largely optimistic about the positive impacts remediation might have on the local economy, real estate value, and recreation on the waterway. These findings suggest that remediation work, in addition to reducing the hazard of legacy contaminants, may be an important element in reducing the stigma surrounding industrialized waterways and could help galvanize ongoing revitalization efforts in riparian cities. This project may serve as a useful case study for environmental managers and city officials in other AOC communities planning their own cleanup work -- in the case of the Sheboygan River AOC, stakeholders feel largely positive, and significantly less worried, about the state of their waterway post-remediation.

The social amplification of risk framework effectively illustrates the interactions between the actors and factors that influence risk messages in AOC waterway remediation projects. While the overarching stations in the original SARF model remain largely congruent pre- and post-remediation, the importance of individual actors and specific methods of communication do change before and after cleanup, and risk perception within the community is significantly altered -- in this case, overwhelmingly reduced -- once the hazard of legacy industrial pollution is removed from the Sheboygan River. This study highlights the primacy of government agencies as a source of public information about waterway remediation, but also reveals that the relevance of individual agencies as information sources may fluctuate over the course of cleanup, as seen in the shift from EPA to UW-Extension as the most frequently cited professional information brokers between interview sets. Indirect communication across a diverse range of media types, from newspaper articles to mailbox flyers to riverside signage, is seen as an effective way to reach various stakeholder groups rather than any single specific information channel. Direct communication through public meetings or interpersonal conversations with community members about the cleanup work are also valued by interviewees, but is cited slightly more frequently before remediation than after remediation, where indirect communication is more commonly referenced.

Implications for outreach and communication emphasize the importance of government agencies as professional information brokers, the necessity of inter-agency communication and collaboration as individual agencies' relevance as information sources may shift over the course of a project, and the utility of both direct and indirect communication with the public through multiple channels over the course of remediation as an alternative to investing in only one specific source or station. While these findings are specific to one AOC community and different patterns may emerge in

other sediment remediation sites or hazard management efforts, the social amplification of risk framework ultimately proved to be a useful analytical tool in the examination of these Sheboygan interviews. By illuminating the various interactions and channels through which risk messages pass within a community, the social amplification of risk framework provides a coherent and useful analytical lens for the public perceptions of sediment remediation work in the Great Lakes and beyond.

CHAPTER 3: EXAMINING THE SOCIAL AMPLIFICATION OF RISK IN THREE GREAT LAKES AREAS OF CONCERN

Introduction

Problem statement

Legacy industrial pollutants, such as sediment-bound polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), heavy metals, and petroleum products are a persistent threat to human and environmental health in the Great Lakes region. A number of waterways throughout the US and Canada have subsequently been designated Areas of Concern (AOCs) due to environmental degradation caused by "significant impairment of beneficial uses...as a result of human activities at the local level" (Great Lakes Areas of Concern, 2017). While sediment remediation work through the Great Lakes Legacy Act (GLLA) and Great Lakes Restoration Initiative (GLRI) has been proven to reduce the hazards that legacy pollutants pose to human and environmental health (Apitz et al, 2005), public perception of risk surrounding the contaminants and cleanup process is a more complicated subject. Remediation projects proposed in AOC communities have been met with a mix of enthusiasm and concern from local residents, and examining the channels through which stakeholders receive information about the hazards in their waterways and how this information shapes their perceptions of risk may explain the occasionally ambivalent responses to what might otherwise be seen as a clear environmental improvement.

Risk and hazard research indicates that public responses to a perceived risk do not always correspond to the quantifiable dangers posed by a given hazard, with dramatic but uncommon dangers like nuclear accidents being perceived as much more dangerous than persistent but mundane threats like legacy waterway pollution that has become normalized over decades of exposure (Kasperson et al, 1988). Public perceptions of risk are further complicated in the case of hazards that are not immediately detectable to the naked eye, like contaminated sediment hidden below the surface of a river (Yamashita, 2009). As a result, community responses to Great Lakes waterway contamination and remediation is complex and sometimes contradictory, with some stakeholders viewing legacy pollutants as a severe health risk that prevents their enjoyment of their local waterways. Others consider the cleanup process itself as an unnecessary threat that will "stir up old sins" rather than truly improving environmental conditions. Some stakeholders further assume an "out of sight, out of mind" mentality despite the known persistence of these aquatic pollutants (McCoy et al, 2014.) The social amplification

of risk framework (SARF) may explain how risk messages associated with waterway contamination produce these varied stakeholder responses to cleanup work: hazards like sediment contamination interact with psychological, social, institutional, and cultural processes in ways that may amplify or attenuate public responses to a perceived risk (Kasperson et al, 1988). The SARF has been applied to a diverse range of natural and technological hazards since its development in the 1980s and was demonstrated to be a useful analytical lens for studying public perceptions of AOC sediment remediation at a single location (Lower, Chapter 1).

Whether the SARF is an appropriate method for comparing important elements of risk perception and communication across different waterway sediment remediation sites is a topic worthy of further exploration, particularly because its structure may provide insights to addressing the challenges posed by the invisible nature of waterway contamination. While the social amplification of risk has proven to be a useful framework for studying the effects of waterway pollution and remediation at AOC sites based on secondary analysis of interview data at a single site (Lower, Chapter 1), it is unclear whether generalizations can be made about the communications channels and risk messages passed along regarding cleanup work across multiple AOCs. To examine the viability of this concept, I analyze interview data collected from residents of three different Areas of Concern that contain sites targeted for sediment remediation work -- the Upper Trenton Channel in the Detroit River AOC, Michigan; the U. S. Steel Site in the St. Louis River AOC, Minnesota, and the Zephyr site in the Muskegon Lake AOC, Michigan -- using the SARF.

The social amplification of risk framework involves the sources and channels of information about a given hazard, the social stations they pass through, the political and social actions produced by the presence of the hazard, along with the ripple effects of how risk messages move through a community and the impacts it generates socially, culturally, and economically (Kasperson et al, 1988). Of these categories, a few are particularly relevant to a cross-site analysis: because of different political entities at work in different locations, one might expect social stations, particularly in the “government agencies” code category, to vary in relevance between sites. The material conditions of AOC remediation sites themselves are also likely to vary, in terms of geography, public access, and the physical, biological, and chemical characteristics that led to their designations in the first place, which may be analyzed through the “personal experience” and “individual senses” codes described by interview participants. Finally, the impacts that these waterway hazards will have on their surrounding communities might also vary because of the differences in the previously mentioned categories, which

could ultimately produce very different risk information models between sites -- or, perhaps, congruence.

If significant congruence in any of these areas exists between AOCs, environmental communicators may be able to more efficiently target outreach through strategies such as partnering with the same social stations in each community to share information and resources about cleanup work, developing diagrams of the dredging process and sharing remediation success stories to illustrate the future potential of sites anticipating cleanup, and focusing communications on how cleanup will address the most commonly cited impacts of pollution through FAQs and fact sheets. Rather than starting from scratch when developing a communications plan for each AOC, finding commonalities in which community actors serve as key information sources, the degree to which citizens are aware of the pollution, and the types of concerns they have about the contamination could streamline the development of outreach material and communication resources for AOCs as a whole.

Though the nature of the hazards that result in AOC designation is similar between each of the sites in this study, many other factors such as site geography, visibility, and accessibility exist that may modify or complicate the production and transfer of risk messages, along with differences in the structure of social networks that exist within individual communities. Are the similarities between the hazards within the AOC designation enough to produce an overarching communications strategy for affected communities, or must outreach be adjusted on a site-by-site basis to account for potential differences? Table 3.1, detailing the analytical components that will be evaluated through site comparison, is provided below.

Table 3.1
Concepts to evaluate through site comparison

AOC site characteristic	SARF component used for analysis	Evidence supporting generalizable AOC communications strategies	Potential communications strategies to be used between sites
Policy context (government agencies and other professional information brokers in the community)	Social stations category ("government agencies", "voluntary organizations", "cultural and social groups", "opinion leaders", and "news media" codes)	Congruence in which social stations are most popularly cited between sites	Partnering with the same types of community contacts to provide them with information and resources about cleanup to share
Physical characteristics of site (whether pollutants are detectable by the senses, public access to the site)	"Personal experience" and "individual senses" codes	Congruence in which physical characteristics of sites are shared between AOCs	Developing diagrams of the dredging process and remediation success stories at similar sites to illustrate future potential
Impacts of pollutants identified by community	Impacts category ("changes in sales", "financial consequences", "regulatory actions", "litigation", "hazard exposure", "community concern", and "confidence in institutions" codes)	Congruence in the impact codes that are most frequently identified between sites	Focusing communications on how cleanup will address the most commonly cited impacts of pollution through FAQs

To investigate this potential for cross-site congruence, I propose three hypotheses to be tested over the course of this project:

1. *Congruence will exist in which social station categories in the SARF are most frequently cited across different AOCs.*
2. *Personal and sensory experience of pollution in the AOC waterways in question will modify community perceptions of risk.*
3. *Risk will be amplified in similar impact categories across different AOCs.*

The three AOC sites selected for this study present a compelling array of similarities and differences within these categories upon a preliminary inspection, making them ideal for comparative analysis. In terms of governance, the Upper Trenton Channel near Detroit and the Zephyr site in Muskegon are both located in Michigan, leading to different state-level agencies and professional information brokers at work in the area than the U. S. Steel site in the St. Louis River AOC, in Duluth, Minnesota. In terms of site geography, both the Zephyr site and the U. S. Steel site are on private property and thus rendered less accessible to the public, while the Upper Trenton Channel flows directly past residential areas and forms the border of some residents' backyards. Finally, in terms of hazard

characteristics, both the Upper Trenton Channel and the U. S. Steel property contain invisible, odorless chemical contamination that is difficult for laypersons to detect below the surface of the water, while the Zephyr site in Muskegon is additionally characterized by persistent odors from the petrochemical byproducts from the former oil refinery on location ("Short-Term Disruptions," 2016). Despite these differences, all three sites are united by their AOC designation and the status of these plans at the time of this study: all interviews utilized in this dataset were conducted before remediation occurred at any of these sites, and project design and contracting is still being finalized at each location as of the time of this report.

Generating cohesive models for communications strategies is of great utility to theorists and practitioners alike, but whether or not this is possible for the topic of AOC waterway remediation remains unknown. The social amplification of risk framework may provide an effective analytical tool for testing these concepts and exploring the differences and similarities between three sites bound by the same federal designation. To that end, I pose my guiding questions: *In what ways does the social amplification of risk surrounding legacy waterway pollutants differ between geographic locations? Can the social amplification of risk framework be used to establish a useful one-size-fits-all model for effective risk communication across different AOCs?*

Methodology

To understand whether the social amplification of risk framework (SARF) provides an adequate lens for comparing risk perceptions of legacy industrial pollutants across different AOC sites, I examine interviews conducted through the Sea Grant Social Science Project in the greater Detroit metropolitan region, Michigan; Duluth, Minnesota; and Muskegon, Michigan, prior to extensive sediment remediation projects conducted in their local AOCs. These areas have been designated as Great Lakes Areas of Concern due to a high level of impairment created by legacy industrial and urban pollutants ("Project Stages," 2016). Using a qualitative coding scheme derived from stakeholder interviews conducted while planning remediation work, I will test the following hypotheses:

> ***H1:*** *Congruence will exist in which social station categories in the SARF are most frequently cited across different AOCs.*
> ***H2:*** *Personal and sensory experience of pollution in the AOC waterways in question will modify community perceptions of risk.*
> ***H3:*** *Risk will be amplified in similar impact categories across different AOCs.*

By analyzing the communications channels that are utilized at each AOC site and their frequency of use, this project will illustrate ways perceptions of risk may diverge or be congruent between geographic locations in federally designated Areas of Concern.

Research Sites

The Upper Trenton Channel, Detroit River AOC, Michigan

The Detroit River is an international waterway connecting the upper Great Lakes and Lake St. Clair to Lake Erie, and has been the site of much industrial and municipal activity on both the American and Canadian sides of its borders. As an important navigational channel and source of cooling water for Detroit's historic manufacturing centers, the river was frequently used as a convenient dumping ground for industrial waste from automotive plants and other heavy industry in the region. This contamination lead to the Detroit River's designation as an Area of Concern under the Great Lakes Water Quality Agreement of 1987 ("About Detroit River AOC," 2016). Main contaminants of concern include PCBs, PAHs, heavy metals, and oil and grease, and nine out of fourteen beneficial use impairments remain despite two (restrictions of water consumption and tainting of fish and wildlife flavor) having been removed since 2011 and 2013, respectively ("Restoring Detroit River AOC," 2016). The Upper Trenton Channel borders Trenton, Grosse Ile, Riverview, Wyandotte, and a number of other "downriver" communities in the greater Detroit metropolitan area and connects the southernmost stretch of the river to Lake Erie, was identified as a hotspot for these legacy industrial pollutants and targeted for sediment cleanup beginning in 2011. The project extends from the BASF Northworks property in Wyandotte to the Firestone property in Riverview (McCoy et al, 2014). Environmental cleanup work has already occurred since AOC's first Remedial Action Plan was created in 1992, including the Black Lagoon GLLA sediment remediation project in 2005 (EPA, 2014) as well as habitat restoration at Belle Isle's South Fishing Pier and Blue Heron Lagoon in 2013 (McCoy, Krupa, and Lower, 2014). Remediation work in the Upper Trenton Channel is currently in the project design stage: initial sediment sampling and feasibility studies have been conducted and the design of the remediation project is underway ("Project Stages," 2016). Thirty-five interviews were conducted with local community members through the Sea Grant Social Science Project in 2014 to produce a needs assessment for outreach and communication in the AOC (McCoy, Krupa, and Lower, 2014).

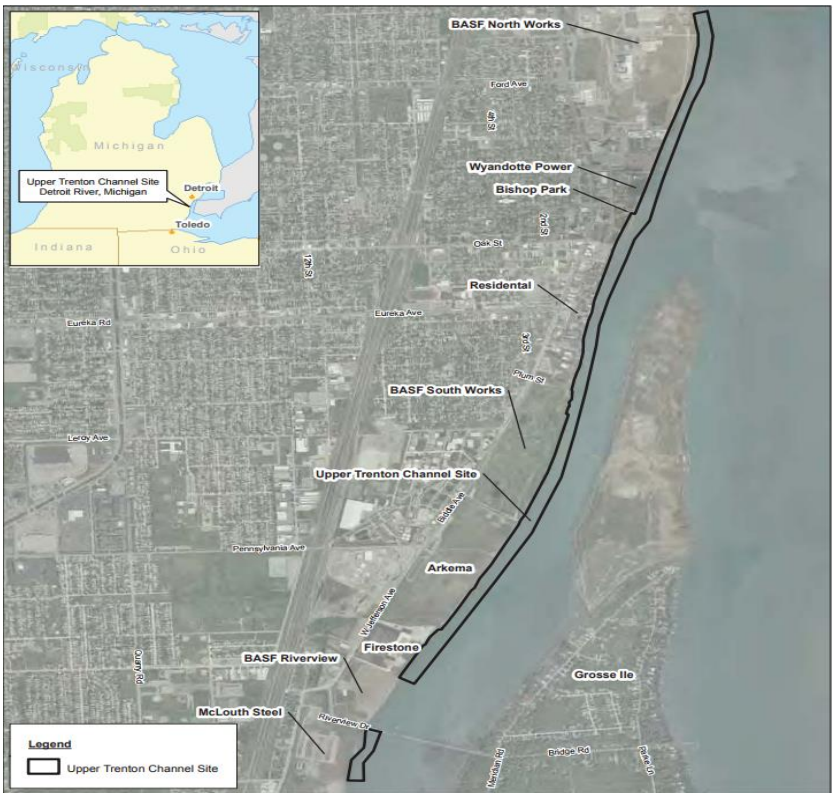


Fig 3.1: Remediation on the Upper Trenton Channel ("Final Focused Feasibility Study Report", 2013)

U. S. Steel Site, St. Louis River AOC, Minnesota

The St. Louis River is Lake Superior's second-largest tributary and flows into the Duluth-Superior Harbor, the largest freshwater port in North America. This AOC is located at the northern Minnesota-Wisconsin border and includes many contaminated areas along 39 miles of the river. The upper river is relatively undeveloped, but becomes more urbanized as the river flows toward Lake Superior. The initial Sea Grant Social Science Project needs assessment found that the St. Louis River and Lake Superior play a significant role in local identity, especially for the Fond du Lac Band, who have occupied the area for centuries (McCoy and Anderson, 2014). Like many Great Lakes waterways, its utility as a shipping channel and coolant source for nearby heavy industry led to significant chemical contamination of the river's sediment, including the deposition of PAHs, heavy metals, PCBs, and dioxins, resulting in eight ongoing beneficial use impairments ("Sediment Studies," 2016). Environmental improvements have been made since the AOC's first Remedial Action Plan was created in 1991. Successes include the return of lake sturgeon to the river, habitat restoration at Grassy Point and Clough Island, and the completion of the Hog Island GLLA sediment remediation project in 2005 (EPA, 2013). Much work remains to fully restore the AOC, and of particular concern is the site of the former U. S. Steel Duluth Works on Spirit

Lake, approximately ten miles upstream of the St. Louis River's mouth. Until it was shut down and designated as a Superfund site in 1981, the steel plant released large quantities of polycyclic aromatic hydrocarbons, lead, zinc, and copper into this section of the river, where these substances continue to pose threats to ecosystem health ("Spirit Lake Legacy Act Cleanup," 2016). The U. S. Steel-Spirit Lake site is currently in the project design stage of the remediation process, with a sediment cleanup plan recently proposed and made available for public comment in August 2016 ("Former U. S. Steel Duluth Works Site," 2016). Twenty-five community interviews were conducted through the Sea Grant Social Science Project to generate a needs assessment in 2014 (McCoy and Anderson, 2014).

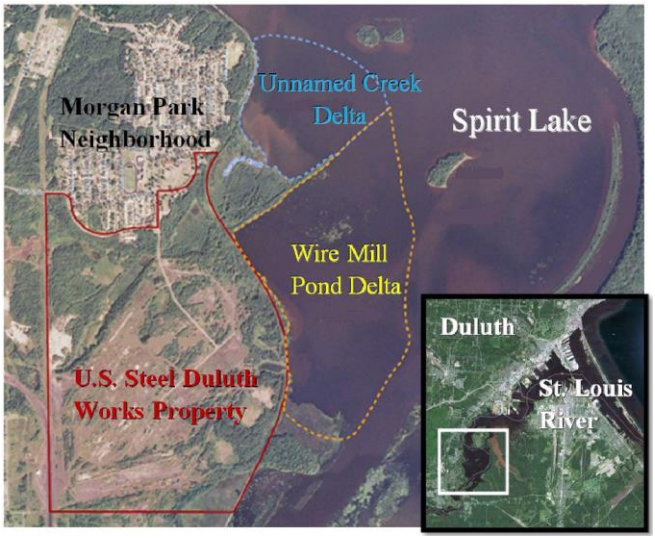


Fig 3.2: U. S. Steel Site Map ("U. S. Steel Site--Spirit Lake", 2016)

Zephyr Site, Muskegon Lake AOC, Muskegon, Michigan

The Muskegon Lake Area of Concern is located close to Lake Michigan's eastern shoreline and includes Muskegon Lake, Bear Lake, and the Muskegon River. It was designated an AOC in 1985 due to the poor water quality and habitat degradation along with contaminated sediment. Decades of discharges from petrochemical companies, foundries, paper mills, and municipal sewage resulted in degradation of benthic organisms, restrictions to fish and wildlife consumption, and loss of habitat quality (EPA, 2013). EPA has already completed two GLLA sediment cleanups in the Muskegon Lake AOC, including Ruddiman Creek and Division Street Outfall. A number of other sites must be restored for the AOC to be delisted, including the former Zephyr site, which of particular interest to this project. In the early 1900s, Muskegon County experienced a small oil boom, leading to the construction of the Zephyr Oil Refinery near the Muskegon River. The refinery converted crude oil to gasoline and other petroleum products, but leaks, spills, and fires over the refinery's lifespan led to contamination of the surrounding

wetlands and waterway. Petroleum products and heavy metals are the primary contaminants of concern at the Zephyr site, with nine out of fourteen BUIs still present in the AOC ("Zephyr Site," 2016). The contaminated property includes a sizeable tract of land atop a bluff as well as wetlands situated below the bluff beside the Muskegon River. The Zephyr site is part of the larger Muskegon Lake AOC, and its proposed EPA cleanup project completed its design phase in 2016: EPA and MDEQ have approved a remediation plan, and project contracting is underway, with cleanup work expected to begin in 2017 ("Zephyr Site," 2016). To generate a needs assessment for the area, 27 stakeholder interviews were conducted in 2015 through the Sea Grant Social Science Project (Nigrelli, 2015).

Fig 3.3: Zephyr Site Map ("Zephyr Site", 2016)

A further comparison of the three sites included in this study is provided in Table 3.2 below.

Table 3.2
AOC Site Comparison

	Waterway contaminants	Beneficial use impairments	Site characteristics	Data available	Dates of GLLA remediation planning	Current status of remediation
Upper Trenton Channel, Detroit River AOC, MI	PCBs, PAHs, metals, petroleum products	9/14 (2 recently removed)	Fast-flowing shipping channel, borders residential area, undetectable contamination	35 interviews conducted in 2014 (10 selected for analysis).	RAP created in 1992, feasibility conducted since 2011, start date currently pending	Project design stage: (sampling and feasibility study complete, remedial design underway)
U. S. Steel, St. Louis River AOC, MN	PAHs, metals, PCBs, dioxins	8/14 (1 removed)	Former steelworks, private property, undetectable contamination	25 interviews conducted in 2014 (10 selected for analysis).	RAP created in 1991, 2016 public comment period, goal of 2025 delisting	Project design stage: (sampling and feasibility study complete, remedial design underway).
Zephyr Site, Muskegon Lake AOC, MI	Metals, petroleum products	9/14	Former oil refinery, private property, hidden from public view, petroleum odors	27 interviews conducted in 2015 (10 selected for analysis).	RAP created in 1987, design phase completed in 2016, cleanup expected to begin in 2017	In progress: (sampling, feasibility, and design approved, project contracting underway).

Data sources

Interview data from each of these three sites was collected through the Illinois-Indiana Sea Grant Social Science Project. A sample of 10 interviews from each site was determined to be both necessary and sufficient to provide an ample range and saturation of stakeholder types and opinions while remaining feasible for the scope of this project from a data management perspective (Saldaña, 2013). This includes 10 of 35 interviews from the Detroit River AOC, 10 of 25 for The St. Louis River AOC, and 10 of 27 for the Muskegon Lake AOC dataset. To control for sampling bias, a list randomizer was used to shuffle the order of the interviews initially collected through the Sea Grant Social Science Project, which were carefully read in their new order to search for substantial responses to both of the following interview questions:

- *"What do you see as the biggest problems or threats facing the waterway?"*
- *"What is the best way for the community to be informed about cleanup and restoration work?"*

If interviewees provided clear, direct answers to both of these questions, the interview will be used as part of the sample. If one or both questions are not answered by the interviewee, the interview was

rejected and the next one down the list was examined for evidence instead until a sample of 10 was collected.

Data processing and analysis

To analyze the stakeholder interview data for this new investigation, categories identified by the original SARF model were used to develop a preliminary coding scheme, which was then applied to the interview transcripts using the qualitative data analysis program Atlas.ti (Friese, 2012). This approach involved three steps: generating the initial codes based on the components of SARF, revising the codes in the context of the interview data, and determining the reliability of the codes (Decuir-Gunby et al, 2011). The codebook was refined over the course of analysis, with iterative changes to codes or definitions tracked and recorded to ensure the validity of results (Creswell, 2012).

As originally discussed in Lower Chapter 1, minor alterations were made to Kasperson et al's original framework in vocabulary and organization in order to update the terminology for clarity. The initial "risk and risk events" box was changed to "hazard: legacy industrial pollutants," and "increase or decrease in environmental risk" was changed to "hazard exposure" in the impacts category. "Attitude changes" was switched to "opinion and behavior changes" so as not to conflict with the understanding of attitude in environmental psychology in more recent literature. In addition, language in the "impacts" category was modified slightly to reflect that loss might not be the only potential outcome of risk perception -- "loss of sales" was modified to "changes in sales," "financial losses" was changed to "financial consequences," and "loss of confidence in institutions" was changed to "confidence in institutions." These minor alterations are not intended to alter the model's categories in any meaningful way, but are meant to facilitate greater clarity in discussion through more precise wording.

The models from each site were compared with one another to determine how risk messages vary between geographic locations and how the influence or relevance of different amplification stations may or may not vary in different communities. Visualizations inspired by Kasperson's original SARF model were generated to illustrate code frequency in each predefined category. Color gradients were assigned to a range of values based on the frequency of responses in each category, with darker values indicating a greater number of quotations in a given category. Table A.2 in the appendix lays out the frequency of responses in each code category before and after remediation.

Results

Data analysis began with a characterization of amplification and attenuation stations and their messages in each Area of Concern separately. In total, 224 pages of data were generated by 30 interviewees, producing 1243 total codes for analysis. Summaries of themes from each site are included below, and a full table of codes for each site can be viewed in Table A.2 in the appendix.

The Upper Trenton Channel, Detroit River AOC, Michigan

Stakeholders from the Upper Trenton Channel received the majority of their information about waterway contamination and the proposed cleanup in their area from direct communication with professional information brokers associated with government agencies, most notably EPA, which led to opinion and behavior changes and organizational responses seen on the community level and hazard exposure, community concern, and financial consequences as the most notable impacts of contamination. Most interviewees cited public meetings that occurred in 2014 as their primary source of cleanup information, and identified these events as key organizational responses from the parties in charge of remediation. Participants discussed the impacts of the pollution and its proposed remediation mainly on the community level, followed closely by impacts felt by individual stakeholders such as riparian property-owners and by local industries like chemical companies and power plants.

Hazard exposure was the most often-referenced impact of waterway contamination in the context of the proposed remediation process: while most stakeholders saw industrial contaminants as a threat to human and environmental health in their community, some worried that the remediation process itself might do more harm than good by releasing those same contaminants into the river during the process of remediation rather than allowing them to stay trapped in submerged sediment. Community concern was identified as the second-most most pressing risk-related impact of waterway pollution, though public perceptions of risk were both amplified and attenuated according to various stakeholders: some interviewees were notably worried about the negative social stigma produced by the history of pollutants in the river and how that might damage the reputation of their community, while others believed that river conditions had already improved enough that “downriver stigma” was naturally decreasing even before this remediation project was proposed. Financial consequences were the third most pressing impact of waterway pollution, with many stakeholders believing that removing the pollutants would be an economic boon to their community and might encourage additional economic revitalization of the surrounding region. Changes in sales, regulatory action, litigation, and confidence in institutions were mentioned only in passing.

U. S. Steel Site, St. Louis River AOC, Minnesota

Interviewees from the St. Louis River AOC relied both on their own personal experience and direct communication with professional information brokers associated with federal and state agencies for knowledge of waterway contamination and the proposed cleanup in their area, leading to opinion and behavior changes and organizational responses from local residents and agencies, with hazard exposure, community concern, and financial consequences as the most prominent impacts of contamination as seen on the community level. The group of stakeholders interviewed in The St. Louis River AOC was comprised of more professionals than private citizens, which was reflected in the greater emphasis on personal experience and direct communication with colleagues as sources of information about pollution and remediation work in the St. Louis River AOC. Interviewees cited myriad government organizations who acted as professional information brokers within the community, including EPA, state agencies in both Minnesota and Wisconsin, and other federal-level agencies. A number of NGOs and voluntary organizations focusing on environmental health were also prominent as social stations, with the St. Louis River Alliance being a notable source of outreach and communication on waterway issues. Three interviewees were members of local tribal authorities: the Fond du Lac band, as well as the Bois Forte and Grand Portage bands, were identified as key cultural groups that served as social stations in the region. Institutional and social behavior was mostly oriented about organizational responses in the form of public meetings and attitude changes noted in residents' relationship with the river, and impacts of the pollution were identified on the community level most prominently.

Hazard exposure was the most often-cited impact residents expressed concern about, followed by environmental stigma and general community concern, and then by financial consequences from the contamination. While interviewees felt that remediation to the U. S. Steel reach was part of a larger set of positive environmental improvements to the St. Louis River, they worried that contamination may have already negatively impacted public health due to bioaccumulation in fish. Changes in sales, regulatory action, litigation, and confidence in institutions were mentioned only in passing.

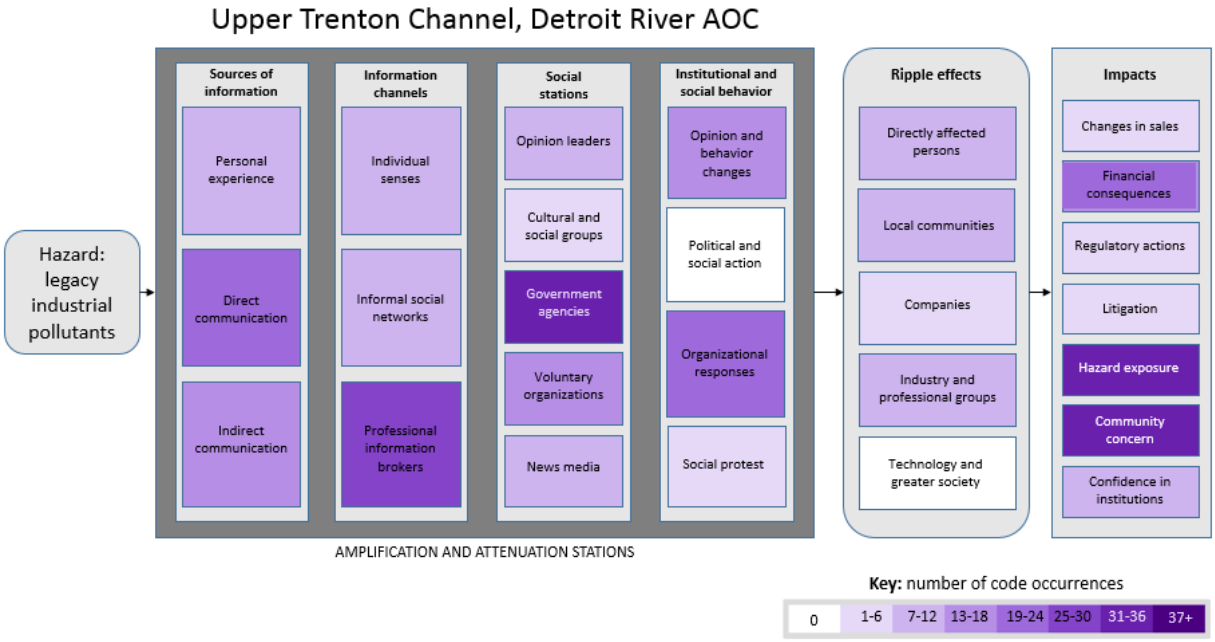
Zephyr Site, Muskegon Lake AOC, Michigan

Residents of Muskegon cited their own personal experiences with the AOC as their primary sources of information, followed by direct and indirect communication gathered from professional information brokers associated with government agencies. MDEQ emerged as the most often-cited social station at this site, followed closely by EPA, and then local and regional governance. Government

agencies were the overwhelmingly dominant information source at this site, with voluntary organizations and opinion leaders coming in a distant second and third. Attitude changes and organizational responses were primary changes to institutional and social behavior, and effects were once again discussed on a community-based level, with some talk of how contamination affects individual stakeholders and companies in the area.

Community concern was cited with slightly more frequency than hazard exposure in the impacts category -- while stakeholders were concerned about the environmental dangers posed by legacy contaminants, they focused slightly more on environmental stigma and public perceptions of the waterway rather than the pollutants themselves. This marks a departure from the trends of the other two sites as well as Sheboygan, Wisconsin (Lower, Chapter 2), all of which suggested that exposure to hazards was the primary concern of stakeholders over public opinion. Financial consequences, as with the other sites, was third on residents' lists of concerns. Changes in sales, regulatory action, litigation, and confidence in institutions were mentioned only occasionally.

The models produced by the social amplification of risk framework from each site can be seen below in Figure 3.3.



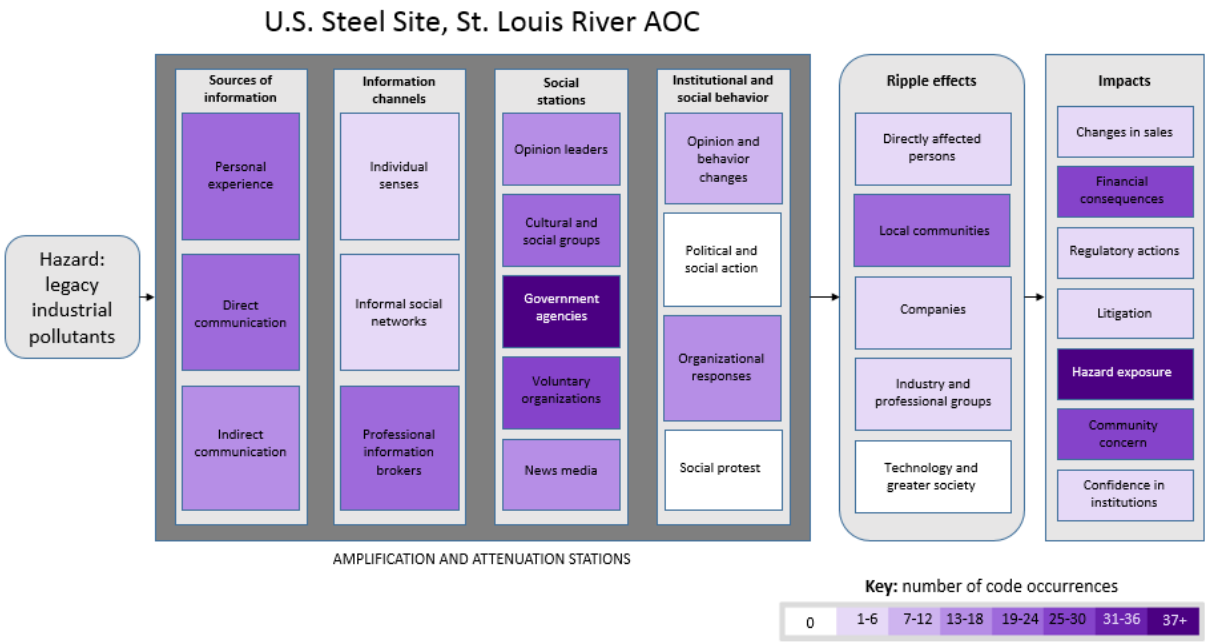


Figure 3.3: SARF Models for Each AOC Site

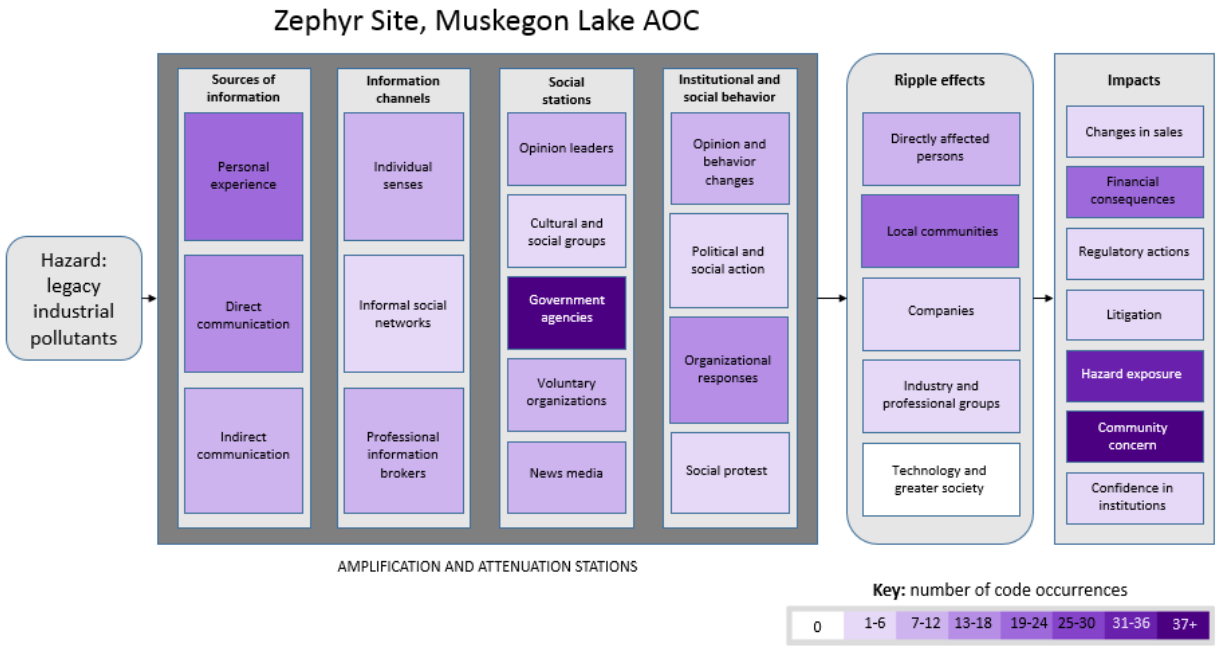


Figure 3.3 (cont.)

H1: Congruence exists in which social station categories in the SARF are most frequently cited across different AOCs.

Analysis revealed this hypothesis to be partially correct: government agencies were most frequently referenced social stations across all three sites, followed by voluntary organizations. Otherwise, the relevance of different social stations varied widely between sites.

Government agencies were the most frequently cited social stations across all sites. Of these, EPA was the most frequent in the Detroit River AOC and the St. Louis River AOC and second most frequent in the Muskegon Lake AOC. EPA was overwhelmingly dominant in the Detroit River AOC, but was one of many government players at the other two sites. State-level agencies were the next most commonly cited government group, such as Minnesota DNR, the Minnesota Pollution Control Agency, and the Michigan Department of Environmental Quality. Municipal government and other federal agencies such as the Army Corps of Engineers appeared to play a much smaller role.

NGOs and voluntary organizations were the second most-frequently cited information source at each site. The most commonly cited organizations in each location had to do directly with waterway management and communication, such as the Friends of the Detroit River, the St. Louis River Alliance, and the Muskegon River Watershed Assembly. Stakeholders in the Detroit River AOC mentioned only two voluntary organizations besides the Friends of the Detroit River, the St. Louis River AOC had 10

separate organizations with the St. Louis River Alliance being most prominent among a blend of others cited with mixed frequency, and Muskegon Lake AOC had seven organizations mentioned no more than one to three times apiece. No clear pattern between sites emerged in the context of this code.

Social and cultural groups were notably prominent in the St. Louis River AOC, but played a very minor role at the other two sites. In The St. Louis River AOC, the Fond du Lac band, and to a much lesser degree the Bois Forte and Grand Portage bands, were the primary sociocultural groups mentioned by interviewees as an important social station: three interviewees worked for tribal authorities on the reservations and had direct insight into the networks of communication within them. These communities operate with their own internal lines of communication: "...we have our own TV station, our own newspaper..." said interviewee 1B, who also suggested powwows and other cultural events as venues to share information about the pollution and cleanup work.

Opinion leaders mostly included personal contacts and interviewees citing themselves, including three participants from Detroit and four from The St. Louis River AOC who identified themselves as having particular sway or a key communications role within their communities. These included local politicians, presidents of boating and kayaking clubs, leaders of NGOs, and environmental professionals who participated in environmental outreach as part of their job. Newspapers did not appear to be a major social station, though all were cited as potential future information channels by interviewees in each site. Multiple stakeholders at each site mentioned that newspaper subscriptions in their communities had been declining in recent years, and suggested that social media or websites might be more appropriate venues through which to communicate cleanup information to local residents.

Further detail on social station cross-site comparison is provided in Table 3.3 below.

Table 3.3
Social Station Cross-Site Comparison

	Upper Trenton Channel, Detroit River AOC		U. S. Steel Site, St. Louis River AOC		Zephyr Site, Muskegon Lake AOC	
Social Station	**Number of times cited**	**Name**	**Number of times cited**	**Name**	**Number of times cited**	**Name**
Government agencies	32	EPA (27), Army Corps of Engineers (2), DNR (1), DEQ (1), "AOC people" (1), local government (1)	59	EPA (14), Minnesota DNR (11), MPCA (7), Minnesota Sea Grant (6), WLSSD (6), Wisconsin DNR (5), Army Corps of Engineers (5), Port Authority (3), USGS (1), FEMA (1),	38	MDEQ (10), EPA (9), WMSRDC (5), Muskegon Watershed Partnership (4), local government (3), Army Corps of Engineers (2), conservation district (1), MDNR (1), NOAA (1) USGS (1), Muskegon Health Department (1)
Voluntary organizations	13	Friends of the Detroit River (9), Detroit River Public Advisory Committee (2), Grosse Ile Nature and Land Conservancy (2)	27	St, Louis River Alliance (8), Harbor Technical Advisory Committee (4), Minnesota Land Trust (4), NRI (3), Izaak Walton League (2), Twin Ports Freshwater Folk (2), Nature Conservancy (2), Douglas County Land Conservation Department (1), Minnesota Environmental Partnership (1)	11	Muskegon River Watershed Assembly (3), Ducks Unlimited (2), Water Resource Institute (2), West Michigan Environmental Network Group (1), Karen Heinz RC&D (1), Muskegon Lake Partnership (1), Michigan Association of Local Environmental Health Administrators (1)
Social groups	5	Rowing club (1), boat club (1), Riverside Kayak (1), citizen research group (1), riparian neighbors (1)	22	Fond du Lac band (13), Bois Forte band (2), Grand Portage band (2), Duluth-Superior Sailing Association (1), Trout Stream Advocates (1), Lake Superior Steelhead Association (1), Arrowhead Flyfishers (1), Coldwater Coalition (1)	4	Local schools (2), local church (1), duck hunters (1)
Opinion leaders	8	Personal contacts (5), Self (3)	15	Personal contacts (10), self (4), AOC coordinator (1)	8	Personal contacts (4), senator (2), local landowner (2)

Table 3.3 (cont.)						
News media	12	Local paper (9), city website (1), local TV news (1), NPR (1)	15	Local newspapers (7), websites (4), TV news (3), local radio (1)	7	Local newspaper (4), website (1), social media (2)

H2: Personal and sensory experience of pollution in the AOC waterways in question may modify community perceptions of risk.

Sensory information and personal experience through living or working close to the remediation sites in this study played a notable role in the risk amplification process for some stakeholders as reflected through the "personal experience" and "individual senses" codes. While the structure of the original Sea Grant Social Science Project interview format did not center sensory experience of pollution as a major theme in its list of interview questions, stakeholders did discuss their personal and sensory experiences when describing their understanding of waterway pollutants. A number of stakeholders who had more direct contact and personal experience interacting with the waterways, whether riparian property owners, environmental professionals, or recreationists, had more concerns about pollutants than other stakeholders who were further removed from the AOC waterways. Pollutants that could be perceived by the senses, whether they were oily sheens or foam observed on the surface of the water or the smell of petroleum products wafting from the waterway, were seen as a cause of alarm for long-time residents in each AOC, but a lack of detectable sensory information with regards to contaminated sediment led to an attenuation of perceived risk for many interviewees. Since some visible BUIs have been repaired at each site and the waterways were no longer as dramatically discolored or odorous as they had been in the past, a number of stakeholders felt their local waterways had already been dramatically improved and were much safer despite the persistence of contaminated sediment below the surface. In the Muskegon Lake AOC, however, the continuing presence of perceptible pollutants in the form of petroleum vapors contributed to a marked amplification of risk for stakeholders who spent time near the Zephyr site, distinguishing Muskegon Lake from the other two AOCs in this study.

The Upper Trenton Channel, Detroit River AOC

The Upper Trenton Channel, a commercial waterway that flows, quite literally, along a number of interviewees' backyards, was the source of some conflicting opinions surrounding the necessity of sediment remediation. This interview set produced eight codes related to sensory information and 11

related to personal experience of pollution on the Upper Trenton Channel. The channel, as a relatively accessible public waterway bordered by residential areas and utilized by many local residents for recreation, seems to be a site of greater contention regarding the remediation process than the other two sites in this study, encompassing a broader range of opinions on the ultimate necessity of remediation and expressing more ambivalence towards its benefits. Local recreationists, such as 3A, the president of a local boat club, were concerned about the disruptions the remediation process might cause to their daily routines on the channel, while riparian property owners like 9A were distressed by the potential for the remediation project to release contaminated sediment into the waterways while dredging was underway. These concepts are reflected in the null risk section of Table 2.6 below, where more stakeholders stated outright that remediation would have minimal to no effect on hazard exposure, community concern, and local finances than at any other site in this study.

This is not to say that stakeholders are unaware of the ongoing issues with contaminated sediment in the Upper Trenton Channel: "I think the challenge is...we all know that there's some sediment problems, and people are kind of thinking, well it's down at the bottom, out of sight out of mind. It's probably a problem but I don't see it, so it's probably okay or something, right?" said interviewee 4A, neatly summarizing a common local sentiment. Interviewee 6A described the look of the channel in the 1970s, riddled with "mats of seaweed, dead fish and oil", and how in contrast today there is "an obvious improvement in how it looks." They went on to suggest that because the proposed sediment remediation work would not change the outward appearance of the channel much, if at all, the benefits of the project might be less obvious to local residents. The combined visibility and public accessibility of the channel may be a mixed blessing for environmental professionals looking to gain public support for remediation work: "if you're not on it, you don't see it," said interviewee 7A. Because many local residents do frequently use the waterway and are deeply concerned with both its well-being and accessibility, a more complex range of opinions on remediation has emerged compared to other AOC sites.

U. S. Steel Site, St. Louis River AOC, Minnesota

With 20 quotes about personal experience but only three quotes dealing specifically with sensory information, stakeholder interviews from The St. Louis River AOC suggested a somewhat more distanced relationship from the U. S. Steel site. The U. S. Steel site, which remains private property, is understandably less accessible to the public than the AOC as a whole, and most stakeholders spoke in terms of the St. Louis River as a whole rather than focusing specifically on the U. S. Steel site where GLLA

remediation is scheduled to take place. The majority of interviewees in this data set had direct experience working with the AOC in a professional capacity, and almost all recognized ongoing sediment contamination as a threat to human and environmental health, but very few cited sensory experiences, either past or present, as their cause for ongoing concern about waterway quality.

Like the Upper Trenton Channel, some stakeholders noted a distinct difference in water quality on the St. Louis River over the past several decades: "...there's not bubbling oil and foam, sheens and piles of foam floating around, so people can get the idea that everything's really clean and the water looks relatively clean...we do have concerns with fish consumption advisories -- you know, tumors and deformities issues," said 2B, noting that despite the visual improvements, less-detectable hazards still persisted below the surface of the water. Three interviewees who were members of the Fond du Lac Band or the Treaty Authority had more direct personal experience with the effects of contamination on the waterway: interviewee 1B described growing up in the reservation along the river where he was instructed to never drink the water, keep it out of his mouth while swimming, and avoid making tea with it. Likewise, interviewees 3B and 10B, both individuals who had grown up on reservations along the St. Louis River, were deeply concerned with the impact of persistent pollutants on traditional food sources for members of their community, specifically fish and wild rice. In comparison, other interviewees also had direct experience with the AOC and its associated contaminants through their work experience, but few relied on sensory information to inform them of the presence of pollutants or shape their opinions of the current health and well-being of the waterway.

Zephyr Site, Muskegon Lake AOC, Michigan

With 12 quotes on sensory information and 17 on personal experience, interviewees in The Muskegon Lake AOC had the most distinct differences in their risk perceptions as modified by proximity and access to their local sediment site. At the Zephyr site, unlike the other two locations included in this study, the primary contaminants of concern were petroleum by-products, which continue to be detectable through sight and smell to local residents, as opposed to the more invisible contaminants in The Detroit River AOC and The St. Louis River AOC. This observable persistence seems to have polarized risk perceptions in The Muskegon Lake AOC: while this site displays the strongest risk attenuation of all three locations in this study, many of the quotes in question came from stakeholders near the site expressing exasperation and concern that other community members who don't live near Zephyr have not encountered the visuals and odors along the waterway that let them know that all is not well in the AOC.

Smell seems to play a particularly critical role in risk amplification at the Zephyr site. Residents 2C, 8C, 9C, and 10C, all discussed distressing odors from the site, describing "rotting oil", a "highly odorous lagoon", and a "stinky smell" coming from the property, accompanied by visual evidence of the pollutants. "It was sticky. It was black. It was obviously highly contaminated," said interviewee 8C, describing conditions at the Zephyr property in the early 2000s. The relative lack of access to the site may be an interfering factor for appropriate risk messages within the greater Muskegon community. Because the Zephyr property is private, relatively shielded from the public view by an embankment and a stand of trees, and surrounded by more private land, residents who do not live near the river have a limited knowledge of the site or its ongoing issues. "...unless they are a riverfront property owner, I don't think [most people] stop to think about it. I think riverfront property owners realize. I think all the rest of us in the county whether we are located near it or not... is a pipe for most people to get their runoff to the lake," said interviewee 1C. "I think if I lived by it I would have a different feeling about it. I would be more engaged," 2C said, echoing the sentiments of other interviewees who lived further from the Zephyr site.

H3: Risk was amplified in similar impact categories across different AOCs.

Risk amplification between sites did indeed follow similar patterns: hazard exposure, community concern, and financial impacts were the top concerns across all three sites, though these impacts varied slightly in order of importance between locations. The specifics concerns within each code category differed by site. Other risk-impact codes also varied by site and were generally of minimal concern.

Community concern and hazard exposure were close in value at each site, and hazard exposure was the primary worry in all sites except for The Muskegon Lake AOC, where community concern and lingering stigma were mentioned just three more times than the actual hazard. Financial consequences ranked third in each of these sites. Every other impact category paled in comparison, with some not being mentioned at all. Risk amplification was actually increased in the Upper Trenton Channel because of the proposed cleanup -- stakeholders, some of whom were riparian property owners and would be directly impacted by the cleanup, worried that disturbing the sediments at all would cause more harm than good. Other interviewees did recognize the problems with leaving them in place and their concern was amplified over the idea that the sediments might not be fully removed and that remediation hadn't started sooner. In The St. Louis River AOC, planned remediation at the U. S. Steel site was seen as one more step towards improvement in the AOC, and was somewhat normalized by the fact that many other cleanup projects, including Superfund remediation, had historically occurred on the St. Louis River. Risk

was attenuated in The Muskegon Lake AOC in two ways described by stakeholders: people who did not regularly access the waterway generally did not know or care about it and so were not particularly concerned about the pollution, combined with a perception that things were already much better because of the other cleanup projects that had been completed in the area in the past. More detail is provided in Table 3.4 below, followed by site-specific findings.

Table 3.4
Risk-Impact Models

	Amplified Risk			Attenuated Risk			Null Risk		
Impact Code	Detroit River AOC	St. Louis River AOC	Muskegon Lake AOC	Detroit River AOC	St. Louis River AOC	Muskegon Lake AOC	Detroit River AOC	St. Louis River AOC	Muskegon Lake AOC
Community concern	13	25	28	5	4	17	7	1	5
Finance	5	18	12	3	1	2	6	2	3
Hazard exposure	19	37	25	7	7	8	6	0	4
Institutional confidence	4	2	2	0	0	0	0	0	0
Legal action	0	1	2	0	0	0	0	0	0
Regulation	0	1	2	0	0	0	0	0	0
Sales	0	0	1	0	0	0	1	0	0

The Upper Trenton Channel, Detroit River AOC

Analysis of interviews from residents of the Detroit River AOC produced a notable amplification of risk surrounding hazard exposure and community concern regarding waterway pollution, with somewhat less amplification surrounding the financial impacts of the contamination. Stakeholders worried about exposure to legacy pollutants and its effects on their health, describing the waterway as "highly toxic", "a polluted body", "contaminated," and a particular health risk to children, subsistence fishermen, and people of childbearing age [3A, 5A, and 10A]. Despite these concerns, proposed cleanup work seemed to intensify risk amplification in some circumstances: riparian property owners and long-time residents in particular identified contaminated sediment as a health threat, but worried that if the remediation procedure was done improperly, polluted sediment could be released into the waterway, creating a greater danger than if it was just left alone at the bottom of the channel. "The sentiment is….if it's laying dormant, you might not want to stir it up," said interviewee 1A.

Inappropriate attenuation of risk was also identified by a number of stakeholders regarding the invisible nature of the contaminated sediment, as expressed by 4A: "I think the challenge is, I think we all know that there's some sediment problems, and people are kind of thinking, well it's down at the

bottom, out of sight out of mind. It's probably a problem but I don't see it, so it's probably okay or something, right?"

Community concern in the form of environmental stigma was also discussed as a result of the area's history of industrial pollution. "We are downriver. We are the forgotten sister of southeast Michigan," said 9A. "Everyone likes to dump on us, and we have some beautiful sites along here but this ugly connotation of being downriver." Several stakeholders saw the remediation work as an opportunity to reduce or remove the stigma associated with the area, hoping that improving environmental health and quality would "help put this history to bed" [5A].

When asked whether remediation would improve opportunities for real estate and local redevelopment, some stakeholders agreed that it would, but many others thought that its effects would be minimal or have no impact at all. Waterfront property was seen as valuable under almost all circumstances anyway, and without visible evidence of pollution or obvious changes to the river post-remediation, many interviewees felt that economic concerns would not be strongly impacted by cleanup work despite the benefits to public health.

U. S. Steel Site, St. Louis River AOC

Interviews from the St. Louis River AOC saw the most dramatic differences between risk amplification and attenuation: despite discussing improvements in water quality in recent years, interviewees consistently identified that there was still a long way to go before the river was fully healthy and safe. Almost all stakeholders acknowledged that legacy contamination was among the primary threats to human and environmental health on the river, though many listed industrial contamination as one of many other threats facing the waterway, including mining upriver, combined sewer overflows, agricultural runoff, and other contributors to beneficial use impairments that were not directly connected to sediment contamination. Interviewees described the river as "contaminated," "toxic," and "a polluted area," and indicated pointed concern about exposure to lingering contaminants. In particular, interviewees involved with tribal authorities [10B, 1B, and 3B] worried about the disproportionate impact of pollutants on members of the local reservation, whose subsistence fishing and consumption of locally grown wild rice might expose them to a greater chemical load than other residents of the greater Duluth and Superior area.

While this group of interviewees was generally well informed about waterway issues, they suggested that the rest of Duluth and Superior might not know about the issue of contamination to the same extent: "People don't really understand so they don't care. I think education is the best way to

solve that," suggested 1B. Lingering environmental stigma was also present despite ongoing improvements to the waterway -- several stakeholders gave a brief overview of Duluth's industrial history and why the public might still be hesitant to interact with the river after its history of contamination. "I don't spend as much time down there as I used to because I'm scared of that water now, it's changed," said 1B. "Especially now that I'm part of the environmental office here, I'm more aware of how they've damaged the water and I'm more aware of how important the water is."

Stakeholders at this AOC tended to contextualize the GLRI-funded U. S. Steel cleanup project as just another step in an ongoing process to improve the AOC, and as a natural continuation of established remediation work rather than a unique project. The Superfund designation of several sites along the river, which have been undergoing remediation work for decades, may contribute to this sense of continuation as well as the propensity to discuss what had already improved in the area in terms of water quality and environmental health. "...[it's] more of the same...the more we clean it up the more useable it is, so it improves, I guess, it keeps our families safe," said interviewee 4B.

Most interviewees suggested that the cleanup work was headed in the right direction, with one respondent identifying inaction as the biggest threat to the river: "...in my mind the biggest threat right now is losing or maybe never getting the momentum to actually clean up these legacy sites. Because for the biology it makes absolutely no difference in the world how many plans you do. It only makes a difference once you actually do the restoration. ...my biggest concern is that we'll spend a lot of time running in circles…" said interviewee 5B.

Stakeholders saw the cleanup as having positive economic impacts for The St. Louis River AOC, including an increase in property values and increased potential for redevelopment, leading to increased job growth and tourism in the area. While a few interviewees indicated irritation with the slow process of planning waterway cleanup or expressed worries that legal action through Superfund and AOC designation may have negatively impacted some of the industries responsible for contamination, they were generally optimistic about the potential for remediation to contribute to the improvement of the St. Louis River AOC.

Zephyr Site, Muskegon Lake AOC

Muskegon had two notable differences from the other two sites: a greater emphasis on community concern than on the dangers posed by exposure to the contamination, and significantly more attenuation of risk in the hazard exposure category.

Community concern was the most frequently cited risk-related code at this AOC, with 28 codes suggesting amplification and 17 suggesting attenuation. When discussing the negative impacts of waterway pollutants, participants gave more value judgments and focused more on community perceptions of and opinions about the contamination rather than the contamination itself. Many of the stakeholders were concerned about the dangers posed by the lingering pollutants from the former Zephyr refinery, discussing oily sheens on the water and the smell of gasoline and "rotten oil" wafting up from the site [10C, 4C]. Hazard exposure was the second most frequently cited impact code, with residents discussing their personal observations of the contamination as well as signage and fish advisories in the area warning them of the contamination. This ability for residents to detect the presence of the hazard with their own senses makes the Zephyr site somewhat unique: the presence of petroleum products, unlike heavy metals, PCBs, and PAHs, can be observed through sight and smell, which may influence individuals' understandings of the amount and severity of the chemicals in question.

Despite nearby property owners and individuals who had experience working on the Muskegon Lake AOC expressing grave concern about these contaminants, other community members who did not have much direct contact with the Zephyr site were comparatively unconcerned about either the pollution or its proposed remediation. "As far as quality of life, most people would never even give it a thought. Environmental people… want to clean up the river. Hey, that's great! But they understand it. I don't understand it. The average Joe doesn't understand it. To us it is like okay, there is the water, let's get in it and go. If it is a little or a lot polluted, we don't know," said interviewee 3C. "I think if I lived by it I would have a different feeling about it. I would be more engaged," interviewee 2C said.

Economic impacts were also discussed at length: stakeholders near the Zephyr property mentioned that neighbors had been reluctant to purchase property nearby due to the smell of petroleum and the knowledge that the site was contaminated, and local government officials discussed hopes that property values in the area would improve once the site was remediated. Redevelopment on the site itself is impossible due to its nature as a wetland, which was a source of consternation for some interviewees, but in general, stakeholders thought the prospects of financial benefits post-remediation were good.

Discussion

After comparing the SARF models for the Upper Trenton Channel, the St. Louis River AOC, and the Muskegon Lake AOC, results indicate that each of these AOCs, despite being labeled with the same

government designation and anticipating similar types of cleanup work, is unique in the communications channels and risk amplification patterns they produce. While common features did emerge, communication plans for each community would need to be tailored specifically to address site-specific concerns and take full advantage of the diverse communication channels within the impacted areas.

The role of government agencies, from federal to state to local, was decidedly prominent in risk communication at each AOC. The Environmental Protection Agency, which is the primary organization in charge of site characterization and designation, was among the most important single communication sources within each community as project planning progressed. State agencies, such as the Department of Natural Resources and the Department of Environmental Quality were identified as other players involved with the project, often working in conjunction with EPA surrounding project planning and outreach. Regional and municipal government was featured far less frequently than any of the previous entities. These findings suggest that federal and state agencies have a particular obligation to provide community outreach material about cleanup work, as interviewees looked to them consistently rather than more local representatives for information about pollutants and remediation. These agencies have a legal mandate to provide this communications material ("Communication with the Public," 2004) Feedback on the efficacy of the content they have already produced, as well as suggestions for improvement in areas where stakeholder concerns have not been entirely addressed, may be highly beneficial to improve their outreach efforts going forward.

NGOs fill a secondary role in communication across all three AOCs, with water-oriented organizations like Friends of the Detroit River and the St. Louis River Alliance actively working towards outreach and communication with communities about waterway health. Ensuring these organizations are in contact with the government agencies planning remediation work may serve to extend communications channels and reinforce important messages about waterway safety within the community. While not relevant to some AOCs, it is critical to recognize tribal sovereignty as in the case of the U. S. Steel site and identify the impact that cultural groups such as the Fond du Lac band have in spreading information within their own communities: outreach to specific sociocultural groups of this nature is an important avenue to consider for environmental justice and equity (Jackson, 2011; Kelley and Covi, 2013). The importance of news media in communicating information about legacy industrial pollutants is significantly less than these other stations, perhaps due to the nature of the hazards themselves and the multi-step, complex cleanup process compared to the types of hazards that make for more exciting stories. The absence of media as a strongly influential social station at any of these sites -- a somewhat unexpected finding based on the extensive body of literature that examines the

SARF through content analysis of news media (Comby et al, 2014; Hart et al, 2011; Claassen et al, 2012) -- may have to do with the nature of hazard communication in news media, and the fact that legacy industrial pollutants are not an especially charismatic threat. News media "is often skewed towards novelty, rarity, and poignancy" (Ley-Garcia et al, 2015), and a non-acute, functionally invisible hazard that has been known about for decades may have failed to attract much media attention even when its removal would be a boon to the affected communities. The relevance of newspapers in the digital age was indicated to be decreasing, while online publications and social media may provide important new avenues for public communication not fully accounted for through the categories of the original social amplification of risk framework.

There is evidence that across all AOCs in this study, legacy industrial pollutants present a largely invisible risk. Yamashita (2009)'s concept of "sense-hidden" risks proved to be an especially valuable idea when analyzing stakeholder responses to waterway pollution. Because the majority of remediation work occurs below the surface of the water and results in minimal changes to the appearance of the river, stakeholders may have a harder time understanding the benefits of restoration work despite its importance to human and environmental health. This invisibility of contaminated sediment may be responsible for the lack of enthusiasm about cleanup work from some interviewees in the Upper Trenton Channel and the distinct attenuation of risk from the stakeholders who did not live or work near the Zephyr site in The Muskegon Lake AOC. Conversely, at the Zephyr site, where petroleum contamination was observable through sight and smell, the stakeholders who witnessed it were particularly adamant about the dangers it posed and upset by the lack of concern demonstrated by other community members who had not witnessed it for themselves. Differences in site access may account for these ranges of opinions between sites. The Upper Trenton Channel is the most visible and accessible for the residents interviewed through this project, and many of the property owners in question expressed real reservations about the cleanup project for fear of remediation stirring up the chemicals that were, sometimes literally, in their own backyards. The St. Louis River is a more intermediate location -- the river itself is publically accessible and is bordered by the historic Morgan Park neighborhood, though the U. S. Steel site itself is private property, so the sense of urgency seemed somewhat reduced in comparison. Opinions in The Muskegon Lake AOC were mixed because the Zephyr site was private property and not easily visible to most residents -- those who lived nearby or had direct experience working on the site tended to be more concerned, but those removed from the site tended to care significantly less.

These sensory differences between sites, and between residents' perceptions of each one, were further articulated in stakeholders' discussion of their personal experiences and historic memories of their local waterbody. Each site in this study is part of a larger AOC, some of which have experienced remediation work going back to the 1980s with original designations through Superfund ("Superfund History", 2017). Previous experience with similar environmental projects in the community seemed to influence stakeholder perceptions of the predicted success of proposed cleanup work, a concept supported by literature on how the availability heuristic shapes risk perception (Eiser et al, 2012). In Duluth, significant improvements have already been seen in the St. Louis River, hence the generally optimistic attitude toward this newest phase of remediation work and the perception of it stalling out as the biggest threat. In the Detroit River, however, a number of cleanup projects occurred in the past that residents were not entirely satisfied with, such as that which occurred in the Black Lagoon. The remediation work on the Black Lagoon first introduced residents to the concept of the silt curtain mitigation technique, which community members do not believe will perform adequately in the faster current of the Upper Trenton Channel (McCoy et al, 2014). The memory-based, emotional, and sensory aspects of how residents discuss pollution in their communities are demonstrated to be key components of how stakeholders articulate their personal experiences of living in an AOC and coping with the knowledge of pollution in their area (Atari, 2010). The "sensory information" and "personal experience" categories of SARF proved to be valuable code categories through which to identify and extract this type of information for analysis in this project.

In the absence of widespread sensory information or personal experience with a given hazard, technical information regarding environmental threats plays an even more important role in shaping residents' perceptions of local hazards. In particular, the invisibility of many environmental contaminants can contribute to numerous interpretations and disagreements about the situation. The ambiguity of environmental contamination inherently increases citizens' reliance on scientific experts to identify both the pollutant and links to adverse health effects (Jacobsen et al, 2017). A number of citizens at various AOCs desired access to better information about the contaminants that would be remediated by the proposed cleanup work: "How is it gonna impact me? Is it going to disrupt my life in any way? Will I be exposed to horrible chemicals?" [4B]. Residents requested clear language and straightforward explanations from scientists about the purpose of remediation in their communities, in "everyday language that everyone can understand" [1B]. Clarification of the purpose of remediation and the specifics of the process are extremely important in light of scientific uncertainty and the ambiguity of harm identified by Jacobsen et al (2017), who noted that communities facing environmental health

threats can experience contention when residents have different or conflicting interpretations of hazards and risks. This was certainly the case in the Upper Trenton Channel, where long-time riparian property owners expressed uncertainty and even outright distrust of the necessity of cleanup because of the silt curtains proposed to contain sediment during the dredging process. Risk managers and communicators might be able to design more effective communications by focusing on "salient, understandable risks instead of the potentially controversial, temporally and geographically distant effects" (Carlton et al 2013) of the contamination and proposed remediation work.

Despite differences in social stations and communication channels in general between AOC sites, some general trends can be identified. Stakeholders at each site were primarily concerned about hazard exposure, environmental stigma, and negative financial consequences, so targeting outreach material to address how cleanup will reduce all three could be a great strategy for increased community buy-in and awareness. In locations where risk perceptions are inappropriately attenuated because of previous cleanup work leading to belief that the waterways in question were almost entirely safe already, outreach material might focus on new remediation work being part of an ongoing series of improvements to make waterways even safer, and on how citizens can make more appropriate choices in their fish consumption and sediment exposure habits to further protect themselves until cleanup is complete and additional BUIs are removed. Raising awareness of lingering contamination through outreach material may be an effective strategy to gain additional community support for remediation work -- if citizens have a better understanding of what hazards exist in their local waterbodies and how those hazards may impact their daily lives, they may be more likely to support the removal of said hazards for the benefit of their community.

Conclusion

This study demonstrates the ongoing necessity of environmental social science research: despite the superficial similarities of each of these AOCs as far as hazards go, each community proved to be very different, and had different hopes and fears about the future of their local waterbody. Without identifying the patterns of risk communication within a community, agencies involved in cleanup run the risk of frustrating and confusing the public, who might feel like their opinion is disregarded or that their fears about pollution and cleanup are being dismissed in the decision-making process. No true one-size-fits-all communication strategy exists, nor is any method guaranteed to be effective, as community relationships with their waterbodies change from site to site. This diversity means that needs assessments and other qualitative community-based research continue to be necessary to identify what

each AOC community might need in terms of effective communication about legacy contaminants and cleanup work.

With the threat of funding loss for the Great Lakes Restoration Initiative to perform remediation, restoration, and monitoring in Areas of Concern, it is more important than ever to emphasize the social, economic, and health-based benefits that waterway remediation brings to Great Lakes communities, for the sake of both citizens and their elected officials. Environmental social science work like the Sea Grant Social Science Project is necessary to understanding the needs of stakeholders and establishing positive relationships between organizations and agencies involved in environmental improvement projects and the communities they serve. Identifying trends across sites in risk perception and communications channels may help make outreach more efficient and effective in the design of future outreach projects, but cannot replace on-the-ground dialogue between researchers and stakeholders to address specific community perceptions and needs. By illuminating both the similarities and differences among AOC communities -- and by showing the public's concern about pollution and support for cleanup work at each site -- this project seeks to illustrate the ongoing necessity of both social science work and environmental remediation itself to improve quality of life and community health across the nation.

CHAPTER 4: CONCLUSION

Waterways categorized as Areas of Concern (AOCs) fall under a unifying government designation because they face a similar constellation of environmental health and water quality issues due to human activities, yet their individual histories, geographies, and the human communities within their borders are unique. Community-level engagement and dialogue with stakeholders in each AOC remains the best way to address individual community needs regarding education and outreach about the health of and any changes to the waterways in question: chronology, site geography, visibility, and local politics all complicate attempts to formulate a single broad communication strategy for environmental professionals working with AOCs. The social amplification of risk framework (SARF) does effectively illuminate some areas where common themes in risk communication can be found, both over the course of cleanup work at a single site and before cleanup begins across multiple locations. Reflections and notes on the analytical process, modifications to the SARF, outreach implications, and potential directions for future research are included below.

Modifications to the SARF

While the SARF proved to be a highly applicable model for analyzing the social impacts of Great Lakes waterway remediation work, some modifications to the original framework were necessary for clarity and coherence in the context of this work. First, the "individual stations" code family was eliminated for the purposes of this project. Because this study performed secondary analysis of interview data in which no questions were asked that would shed light on interviewee's cognitive processes (the original SARF categories in this section were "attention filter", "decoding", "intuitive heuristics", "evaluation and interpretation", and "cognition in social context") it seemed inappropriate to attempt to extrapolate this information from interviews that were never designed to provide insight in these categories. This decision was supported by historic applications of SARF, particularly one by Renn (1992) that determined it was "infeasible to reconstruct the behavioral responses of individuals" to past hazard events, and so asked for hypothetical responses instead. Due to the limitations imposed by secondary data analysis and the nature of the original questions, which did not delve into individual cognitive and decision-making processes, I felt it was most appropriate to drop this code family as a whole from this project's analysis.

When developing a coding strategy for this project, the language used in Kasperson et al's original framework was updated for clarity in a few instances -- the initial "risk and risk events" box was changed to "hazard: legacy industrial pollutants" to avoid the conflation of risk and hazard in the literature. Likewise, "increase or decrease in physical risk" was changed to "hazard exposure" in the impacts category. "Attitude change" was changed to "opinion and behavior changes" based on usage of the term attitude in more modern environmental psychology literature. In addition, language in the "impacts" category was modified slightly to reflect that loss might not be the only potential outcome of risk perception -- "loss of sales" was modified to "changes in sales," "financial losses" was changed to "financial consequences," and "loss of confidence in institutions" was changed to "confidence in institutions." The need for clearer language came about partially through my own reflection during the coding process, and partly through discussion with committee members, and reflected an iterative process. These minor alterations were not intended to alter the model's categories in any meaningful way, but were meant to facilitate greater clarity in discussion through more precise wording.

New codes for "amplified risk", "attenuated risk" and "null risk" were added and were used to analyze the impact categories in particular. Each risk code was associated with an impact code -- I determined that risk perception within this scheme was inherently linked to impacts articulated by stakeholders, because risk perceptions are triggered and modified by changes in the physical world, whether fully material (such as hazard exposure) or psychological (such as community concern), and do not exist independent of the hazard itself. Visually representing these codes in the SARF models for each site proved very difficult -- several strategies for color-coding the impact categories were discussed, such as a color grid or gradient that showed amplification in red, attenuation in blue, and null risk in gray, to visually represent the proportion of these codes within each impact category. These plans were ultimately rejected because they produced a great deal of visual clutter and made the impact categories difficult to interpret coherently, so the concept of color-coded risk-impact categories was saved for a separate table within the text to avoid illegibility. An interactive digital model has the potential to avoid these issues, but the limitations of the SARF's form on paper prevented these plans from being fully realized.

Two novel potential code categories emerged that were not adequately captured by SARF: academia and social media. Kasperson's original model was developed in the mid-1980s, and so social media and the internet as the communication channel we recognize today simply did not exist. Likewise, academia, in the form of Sea Grant and Extension programs at these AOC sites, emerged as important players that did not fit neatly into any of the existing social station categories. While Sea Grant and

Extension are accurately identified as “professional information brokers”, they are neither government agencies nor NGOs, but academic research organizations.

As recommended in a number of other studies on SARF, trust emerged from time to time as a modifying factor in risk communication (Frewer et al, 2000; Kasperson and Kasperson, 1992). While this potential new code did not occur frequently (which may have been due to the structure of the interview questions, which were deliberately designed to avoid placing blame on any party for the pollution because of the participatory and voluntary non-federal partnerships that are responsible for GLLA funding (McCoy and Anderson, 2012)), it did occur enough to be noted as a potential “other” code that nevertheless did not fit perfectly into Kasperson’s original model. Within the SARF, a code for trust would be included in the “individual stations” family that was discarded from this analysis due to the difficulties in identifying participants’ cognitive processes that informed their decision-making because of the nature of the original interview questions. With this in mind, the potential new code for trust was ultimately incorporated with the “confidence in institutions” impact code, but could certainly exist independently in a modified coding scheme.

A fully updated model used for this project might look like this:

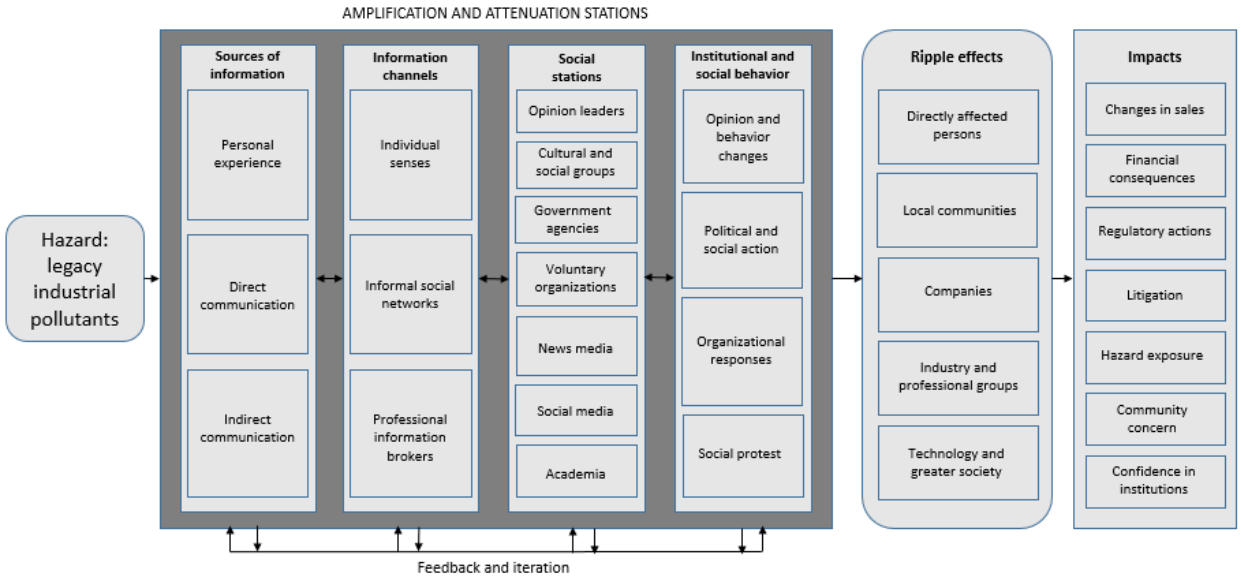


Figure 4.1: Modified SARF Framework

The two primary additions to this version of the model are categories for “academia” and “social media.” Adding the category for academia solves the categorization issue surrounding important actors

like Sea Grant, Extension, and other university-based research. Social media simply did not exist at the time of SARF's original development, and ignoring the role of online content and dialogue misses a major aspect of modern communication that was repeatedly identified in interviews.

The "ripple effect" category, while originally portrayed as a series of concentric circles to aesthetically reinforce the concept of impacts spreading outwards in a community, proved to be somewhat difficult to read in Kasperson's original model. This updated version uses a series of boxes instead to promote legibility, not to critique the original metaphor.

In future projects, the "individual stations" code family could be re-introduced, but only with a research design that provides a method of identifying individuals' cognitive and decision-making processes through interview or survey response. Within the scope of this project design, identifying these processes was not feasible, so the code family was removed.

An interactive digital SARF model, such as one produced in Adobe Flash or another web tool, could be an even more effective strategy for visual communication. Clicking on each box in the framework, for example, could provide a definition of the code in question and list the sub-codes contained within. This would be especially useful for the social station section, where a drop-down list of the individual actors within each category (i.e., government agencies) and their relative frequency could be provided. Additionally, the changes in risk -- amplification, attenuation, and null -- for each impact category could be represented through colored overlays -- toggling between amplification and attenuation in each impact category would give a clearer idea of where risk perceptions are increasing and decreasing relative to one another. A digital tool of this nature would improve the organization and legibility of the SARF as well as allow for the consolidation of the other data tables previously kept separate in this analysis.

Critiques and challenges

The social amplification of risk framework has been critiqued from a number of directions since its first publication. Some researchers have criticized the amplification metaphor itself, and are concerned that the implication of using this signal theory metaphor implies that there is some "true" level of risk, which is then "distorted" by public perceptions (Pidgeon, Kasperson, and Slovic, 2003). Pidgeon et al. responded that all knowledge of risk is a product of social construction and judgment, and that acknowledging this is essential when dealing with any public understanding of a hazard. Other critics argued that the semantic framing of the social amplification of risk downplays the importance of risk attenuation, which can have societal impacts just as dramatic as intensification. Despite the name of

the framework and the subsequent research emphasis on amplification processes in other studies over the years, the creators of the framework have always emphasized that the model is intended to describe both attenuation and amplification, and that both effects are of equal importance (Pidgeon, Kasperson, and Slovic, 2003). In the spirit of this original intention, I have been careful to include both amplification and attenuation while coding for risk, as well as a "null risk" code when stakeholders indicated uncertainty or lack of change in their risk perceptions regarding waterway remediation. Both, in the context of this project, are very important elements, and neglecting that risk attenuation with regard to sediment pollution may actually increase harm from willing exposure (Burger, 2000).

While the SARF can be used to identify various actors and communication channels within a community, it does not lay out causal pathways of information transfer. While correlations can be identified through SARF, other researchers using the framework in the past (Renn, 1992) have been quick to remind readers that this does not indicate causality. Because of the non-linear, iterative nature of risk communication, clear causal pathways may not be possible to establish using this model.

The social amplification of risk is not a theory in the classical sense, but instead provides a broad conceptual framework for classifying and ordering social phenomena and suggesting relationships that can then be investigated empirically (Renn, 1992). Researchers acknowledge that it is difficult to test empirically and particularly hard to seek outright falsification (Pidgeon, Kasperson, and Slovic, 2003), a challenge faced when developing the methodology for this thesis research. While the model cannot truly be falsified or disproved, the degree of appropriateness in application to a given subject can be tested -- in the case of this research, it proved to be an adequate framework for secondary analysis of interview data around a novel hazard. Renn (1992) suggests its real utility lies in its ability to generate hypotheses and serve as an alternative model of risk that explains what competing concepts, such as strictly psychological or cultural approaches to risk, cannot. This framework was always meant to be built on and modified -- as I found in my study, not all the concepts and categories laid out in Kasperson's original model were able to be applied to the data I used, while new codes emerged that were only partially or imperfectly captured by the categories from the initial framework. Kasperson (1992) suggests that one of the framework's greatest strengths in in "providing an overall framework in which to locate a large array of fragmented empirical findings" (Pidgeon, Kasperson, and Slovic, 2003) -- a concept at the heart of my own application of SARF in this project.

As noted in the original Sea Grant Social Science Project, the degree of generalizability at each site is limited by both sample size and sampling technique. The Sea Grant Social Science Project, with its sample size of 25-35 interviews per site and its success at attaining rich, detailed descriptions of

phenomena, achieved its qualitative research outcomes, but its scope naturally limits the ability to draw certain conclusions. Not all stakeholder viewpoints have necessarily been represented in the original studies at each site, though the original researchers strove for saturation of ideas and selected an intentionally diverse collection of individuals from each study site in order to hear a range of public opinions. However, because of the small sample size and the lack of truly random selection in the original interview protocol, some community voices may be over-represented while some may be underrepresented, and the original researchers acknowledge that they represent a detailed cross-section of local opinions rather than a truly generalizable one (McCoy and Anderson, 2012).

By using a sub-sample of the original Sea Grant Social Science Project interviews, concerns about over- and under-representation in opinions are amplified even more strongly, as a selection of ten stakeholders from each site provides only a snapshot of the diversity of opinions and knowledge within each site. Indeed, secondary analysis of qualitative data is always a challenging process because some degree of context-based detail and nuance collected by the original interviewees may be lost when analyzed by a third party, or when samples are further subdivided to produce a new work (Irwin, 2013). Fully transcending these inherent limitations in project design, particularly in the context of secondary data analysis, was beyond the scope of this graduate thesis. However, future research, particularly in the form of community surveys that are able to reach many more individuals at a given site and thus ensure greater saturation and validity, holds promise in developing the conceptual framework laid out though this project into a truly robust tool for analyzing community perceptions of risk on a greater scale. Mixed-methods research could combine the best of both qualitative and quantitative techniques, and may be a promising venue for academic research projects on this topic in the future.

A frequentist approach is a straightforward way to analyze and simplify complex data (Hampel, 1998), though this work is not purely frequentist and does rely on extensive description of the information included on the sub-code level within the project coding scheme. Frequency alone does not establish the intensity or opinion of a subject's feelings about a given code category -- for instance, while newspapers were mentioned regularly as a social station, many interviewees disliked or distrusted the quality of reporting in their local paper even while reporting them as a potential channel for future outreach. Categorizing a social station or impact category as especially important due to frequency of occurrence alone without taking into account the context provided by stakeholders would be a mistake, and this project seeks to control for the inherent issues with this strategy by contextualizing and analyzing full stakeholder quotes rather than performing analysis via keyword search and subsequent frequency counts alone.

Despite the limitations of both the original dataset and the scope of this graduate thesis, my hope is that this project suggests a valuable new use for SARF by demonstrating its applicability as an analytical tool for assessing risk communication in waterway cleanup work. It highlights similarities and differences in risk perceptions and communication patterns between AOCs in an organized and novel way, and I believe its greatest strengths may ultimately be in laying the groundwork for future studies that implement the most valuable aspects of SARF, either in initial project design or in analysis of stakeholder data.

Outreach implications

The target audience for this thesis work is largely professionals designing risk communication schemes associated with cleanup efforts: environmental managers at the state and federal level, or those associated with Sea Grant, Extension programs, and local NGOs who have a significant role as waterway-oriented communicators. Introducing environmental managers to the SARF can reinforce the idea that communication is iterative and non-linear, and that formal communication channels are not the only ones utilized when addressing waterway issues, though they are nonetheless very important. Emphasizing that risk communication happens through many different channels, including non-expert sources, may encourage professional information brokers to foster even more community dialogue as well as reach out to some of the other social stations identified within their community in order to clarify any questions and establish a consistent and reliable narrative about the process and benefits of remediation work.

Introducing the SARF to risk communicators may also give these professionals some perspective: they are not the only sources of information within their community, and cannot truly control what information or perceptions about the cleanup work, its benefits, or the original pollution are actually circulating within their community. Risk perceptions are amplified and attenuated by many factors, and no single agency or entity can take full responsibility for the understandings residents have about their waterway. Incorrect information, inappropriate amplification or attenuation of risk, and uncertainty cannot be entirely controlled for, and understanding that this is a natural and to some degree inevitable part of information transfer may help risk communicators more accurately understand their degree of success in community outreach efforts (Pidgeon, Kasperson, and Slovic, 2003).

SARF makes for a useful organizational tool for planning effective outreach strategies in particular. Examining the social stations cited most popularly by stakeholders at a given site, both on the individual code and sub-code levels, outlines key nodes of information transfer within the community

about waterway hazards -- who are important players to bring on board if communication about waterway hazard removal is to reach as many community members as possible. Examining which impact codes are discussed most commonly, and in what ways, is an excellent shortcut for beginning to develop a set of publically accessible FAQs about how remediation might address these negative outcomes of pollution articulated by community members. Before-and-after comparisons like the one performed in Sheboygan might also be useful for analyzing how the process of remediation itself intervenes in the risk communication process. By noting any shifts in social stations before and after cleanup, communicators may need to plan to partner with different agencies and groups at different phases of the cleanup process -- establishing relationships with these various groups early on and assisting in the transfer of communication and outreach responsibilities over the course of the cleanup will ensure stakeholders can have their questions answered at any point during the remediation process.

Communication and dialogue between as many professionals as possible can ensure information is passed along correctly and misinformation is not accidentally propagated. Having project leads in remediation work look to the major social stations, such as government agencies at the state and local levels along with NGOs, for additional waterway information may be a worthwhile place to begin. Introducing background information about the site and providing some answers to FAQs project leads might field from the public may be a good strategy, as well as providing access to online information like the Great Lakes Mud website that they can both use to educate themselves and recommend to curious residents nearby.

Directions for future research

The categories used in the SARF could be an efficient way to organize initial questions in future research projects: asking about specific impacts, ripple effects of the hazard within the community, and sources of information based on the amplification station categories could provide a robust outline for surveys or semi-structured interviews. A similar sampling scheme to the original Sea Grant Social Science Project could be utilized, but if a survey was designed, the opportunity to spread it further and more randomly than a semi-structured interview process could provide additional validity and generalizability. For surveys in particular, researchers could quantify the data from the outset by having stakeholders list information sources in order of relevance or quality, for instance, or ranking their own degrees of concern about impact categories. This would produce much tidier data than this secondary analysis of qualitative data, though it would lose much of the nuance that semi-structured interviews provide: the rich, detailed understanding achieved through stakeholder interviews would not be achievable through

survey methods. Qualitative and quantitative approaches each have their respective strengths and drawbacks – with this in mind, a quantitative approach could therefore serve as a compliment to, rather than a replacement for, semi-structured interviews in future research.

Development of a streamlined set of frequently asked questions (FAQs) for improved community outreach is made possible through the SARF. The impact categories most discussed across sites centered heavily on hazard exposure, community concern, and financial consequences. Starter FAQs addressing hazard exposure would include the questions and answers about the technical nature of the pollutants like how they are bound in the sediment, their associated negative health outcomes in fish, wildlife, and people, and how the sediment remediation process will remove or greatly reduce the potential for exposure. FAQs drawn from the community concern idea could highlight successes at other AOCs in terms of increased waterway and waterfront real estate usage for recreation, highlighting the narrative of communities returning to the waterbody once it is cleaner and safer. FAQs about financial consequences could highlight the economic benefits of remediation as cited in the Brookings Institute report (Austin et al, 2007) and other studies and success stories of Great Lakes revitalization work, as well as being transparent about the remediation work's funding structure. Some examples are included below:

- *What sediment pollutants exist in my waterway?*
- *How do these pollutants affect wildlife and people?*
- *How will these pollutants be removed?*
- *Will dredging stir up pollution and send it downstream? Won't this cause more problems than it solves?*
- *How will the ongoing cleanup process affect daily life in my community?*
- *What will my waterway look like after cleanup is complete? What other changes can I expect once the project concludes?*
- *Who is participating in the cleanup work? How is this project being funded?*
- *Where can I learn more about the waterway cleanup work in my community?*

Summary and political context

Chapter 2 demonstrated the utility of SARF as a tool for examining how the social amplification of risk changes over the course of a hazard remediation project. While community members in Sheboygan turned to the same social station categories for information about waterway pollutants both before and after cleanup, the federal agencies like EPA who catalyzed the project and were cited most in pre-remediation interviews were backgrounded slightly to more local players after cleanup was complete, indicating a shift in communication dynamics within the community. Hazard exposure, community concern, and financial consequences were identified as the most significant impacts of

legacy industrial pollutants both before and after remediation was complete, but post-remediation interviews showed that the public's perception of waterway risk was greatly reduced in each of these categories after the successful completion of sediment removal in the Sheboygan River. Findings from this chapter indicate the critical role of government agencies as professional information brokers in AOC communities, and also suggest that the physical act of waterway remediation has social impacts as well, with stakeholders indicating that they felt the river was cleaner and safer, that the local community felt more positively towards the waterway, and that economic opportunities would be improved along with environmental quality.

Chapter 3 used the SARF to draw out the similarities and differences in risk perception between three different AOC communities in an attempt to develop a comprehensive model for best communications practices across AOCs. Identifying the most relevant social stations for sharing risk information along with the most commonly referenced negative impacts of contamination at each site produced results that further supported Chapter 2's findings: at each AOC in this study, professional information brokers primarily associated with government agencies play a key role in spreading information about legacy industrial pollutants. As in Chapter 2, stakeholders in each community were most worried about being exposed to the pollutants, the community concern and stigma the pollutants caused, and the negative financial consequences of their continuing presence in the local waterways. Political, geographic, and material differences between each AOC site did, however, complicate the possibility of developing a one-size-fits-all outreach model for environmental professionals. Federal and state agencies had differing degrees of relevance at each site, the relative accessibility of each waterway influenced the degree of community concern it inspired, and the nature of the pollutants themselves -- whether visible, odorous petrochemical byproducts or invisible, odorless chemicals hidden beneath the surface of the water -- altered public opinion of exactly how severe the risk of their presence was, and thus how important their removal through remediation would be. Orienting communications material about waterway remediation projects to address hazard exposure, community concern, and financial consequences and planning to share it through professional information brokers from government agencies in AOC communities is a good first step for designing outreach associated with Great Lakes restoration, but the distinct differences at each site identified by this analysis point to the continued necessity of direct engagement with specific AOCs to identify the unique concerns and communications needs of each community.

When taken together, these two chapters illustrate the continuing relevance of the SARF as an analytical tool for environmental problems produced by modernity, and then utilize the framework's

components to test the potential of formulating a general set of best practices for communication around AOC remediation. Broad strategies were successfully identified, but so were complicating factors that indicate the ongoing necessity of environmental social science research that engages directly with stakeholders in cities targeted for waterway remediation work to truly address the nuances of community concerns. However, the proposed defunding of the Great Lakes Restoration Initiative, the Great Lakes Legacy Act, and other remediation programs as outlined in the 2018 fiscal budget plans would potentially eliminate not only the possibility of these focused community outreach efforts, but of waterway cleanup efforts as a whole.

This project originally stemmed from a desire to see if social science data originally collected for a series of Illinois-Indiana Sea Grant needs assessments could be used for a new purpose, and if examination and comparison of this data through a fresh analytical lens would provide novel insights into effective risk communication strategies that might not be readily available when examining findings from these sites individually. However, after the November 2016 presidential election and subsequent changes in national environmental politics, the concept of an efficient analytical tool for Great Lakes science communication took on a new urgency. In the wake of the significant cuts proposed in the president's budget for the 2018 fiscal year for the Great Lakes Restoration Initiative (Soffen and Lu, 2017), environmental agencies on the federal, state, and local levels may find themselves with limited financial resources for remediation work and outreach in AOCs across the United States. An analytical framework that can utilize existing social science data to identify similarities and points of divergence in public understandings and communications needs across Areas of Concern may serve as a useful tool for making community outreach more efficient and effective for environmental professionals facing a newly restrictive time or financial budget in the future.

Reducing or eliminating funding for AOC remediation work and outreach efforts, as the president's budget for the 2018 fiscal year suggests (Ellison, 2017), would have profound negative impacts on AOC communities still waiting for their associated waterways to be remediated. Preventing government agencies like EPA and NOAA from communicating effectively with the public by reducing funding for outreach compromises the most important information channels about hazards in these Great Lakes communities. NGOs, social and cultural groups, community leaders, and even local government officials have neither the reach nor the efficacy in spreading risk information as compared to federal and state-level agencies. Leaving contaminated sediments in these waterways will continue to expose citizens to harmful chemicals with documented negative health outcomes, further straining public healthcare. The long-lasting stigma of these industrialized waterways and their surrounding

communities as dangerous hotbeds of pollution would likely persist, leading to continued stress and anxiety in residents who worry about exposure to contamination and who may shun their rivers even further. This perception of a poisoned industrial region is likely to discourage redevelopment and subsequent economic revitalization in many of these communities (Zhuang et al, 2016) -- precisely the opposite of what the proposed budget allegedly seeks to catalyze across America.

Strong bipartisan support still exists for the Great Lakes Restoration Initiative and its associated AOC cleanup work (Higgins, 2017), and the aforementioned budget cuts have not been agreed to as of the time of this writing. It is my hope that this project will complement ongoing agency communications and help streamline and refine the design of future research projects on Great Lakes restoration work, rather than attempting to establish a vague new template for communication strategies if in-depth studies like the Sea Grant Social Science Project are deprioritized or defunded under a limited federal budget. The results of this research suggest that supporting, not eliminating, Great Lakes restoration and outreach will lead to a healthier environment, a greater sense of safety and security in waterway communities, and opportunities for economic revitalization and growth -- all qualities that can truly make the Great Lakes region “great again.”

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APPENDIX A: PROJECT CODE TABLES

Table A.1
Chapter 2 Pre- and Post-Remediation Coding Results

	Pre-remediation	**Post-remediation**	TOTALS:
Affected:community	23	13	36
Affected:company	2	6	8
Affected:individual	6	1	7
Affected:industry	2	0	2
Amp:behavior:attitude	30	16	46
Amp:behavior:orgresponses	13	16	29
Amp:behavior:socialprotest	0	0	0
Amp:info:professional	23	21	44
Amp:info:senses	3	5	8
Amp:info:socialnetwork	8	3	11
Amp:infosource:directcomm	21	18	39
Amp:infosource:indirectcomm	24	19	43
Amp:infosource:personalexp	12	12	24
Amp:social:gov	36	26	62
Amp:social:newsmedia	16	12	28
Amp:social:ngo	2	2	4
Amp:social:opleader	9	6	15

Table A.1 (cont.)			
Amp:social:socialgroup	10	2	12
Impact:commconcern	39	27	66
Impact:finance	31	16	47
Impact:hazardchange	40	38	78
impact:institutionconfidence	9	0	9
Impact:legalaction	1	4	5
impact:regulation	4	1	5
Impact:sales	0	4	4
Risk:amplified	50	2	52
Risk:attenuated	14	42	56
Risk:na	11	14	25
Other	3	9	12
TOTALS:	442	335	777

Table A.2
Chapter 3 Cross-Site Coding Results

	Detroit River AOC	St. Louis River AOC	Muskegon Lake AOC	TOTALS:
Affected:community	11	21	23	55
Affected:company	5	5	5	15
Affected:individual	7	6	7	20
Affected:industry	7	2	1	10
Amp:behavior:attitude	13	10	12	35
Amp:behavior:politicalaction	0	0	2	2
Amp:behavior:orgresponses	23	14	13	50
Amp:behavior:socialprotest	3	0	2	5
Amp:info:professional	25	20	12	57
Amp:info:senses	8	3	12	23
Amp:info:socialnetwork	10	6	5	21
Amp:infosource:directcomm	24	23	14	61
Amp:infosource:indirectcomm	18	15	12	45
Amp:infosource:personalexp	11	20	17	48
Amp:social:gov	32	59	38	129
Amp:social:newsmedia	12	15	7	34
Amp:social:ngo	13	27	11	51
Amp:social:opleader	8	15	8	31
Amp:social:socialgroup	5	22	4	31
Impact:commconcern	31	29	50	110
Impact:finance	19	28	19	66
Impact:hazardchange	34	44	35	113
impact:institutionconfidence	8	4	2	14
Impact:legalaction	3	1	4	8
impact:regulation	1	1	4	6

Table A.2 (cont.)				
Impact:sales	3	3	1	7
Risk:amplified	33	55	47	135
Risk:attenuated	14	10	18	42
Risk:na	18	4	8	30
TOTALS:	399	453	391	1243

Table A.3

Project Codebook for Atlas.ti

Class	Family	Code	Abbreviation	Definition
Amplification	Sources of information	Personal experience	Amp:infosource:personalexp	Information collected from personal experience/observation in the past.
Amplification	Sources of information	Direct communication	Amp:infosource:directcomm	Direct communication with cleanup officials or other stakeholders who shared info about the project.
Amplification	Sources of information	Indirect communication	Amp:infosource:indirectcomm	Communication in the form of written content, signage, flyers, etc.
Amplification	Information channels	Sensory information	Amp:info:senses	Discussion of info about the contamination gathered personally through the five senses (i.e. seeing or smelling pollutants)
Amplification	Information channels	Informal social networks	Amp:info:socialnetwork	Discussion of info collected through conversation with other stakeholders, "through the grapevine".
Amplification	Information channels	Professional information brokers	Amp:info:professional	Discussion of info shared by professional information brokers (i.e. state and federal outreach coordinators).
Amplification	Social stations	Opinion leaders	Amp:social:opleader	Community leaders whose opinions may influence that of their neighbors (i.e. church officials, tribal leaders, neighborhood elders, respected activists).
Amplification	Social stations	Social and cultural groups	Amp:social:socialgroup	Informal social organizations not normally oriented around the hazard (i.e. church groups, homeowners associations).
Amplification	Social stations	Government agencies	Amp:social:gov	Federal, state, local, and municipal authorities.
Amplification	Social stations	Voluntary agencies	Amp:social:ngo	Nongovernmental agencies and citizen groups (i.e. Riverkeeper, park friends groups, citizen coalitions).
Amplification	Social stations	News media	Amp:social:newsmedia	Newspapers, television stations, radio, and internet news media.
Amplification	Institutional and social behavior	Opinion and behavior change	Amp:behavior:attitude	Changes in feelings about the impacted waterway including the creation of stigma.
Amplification	Institutional and social behavior	Social and political action	Amp:behavior:sociopolaction	Organized stakeholder responses like petitions, town hall meetings, etc.
Amplification	Institutional and social behavior	Organizational responses	Amp:behavior:orgresponses	Responses and actions from governmental and NGO groups in response to hazard.
Amplification	Institutional and social behavior	Social protest and disorder	Amp:behavior:socialprotest	Citizen outrage, protest, or conflict generated by news of the hazard.

Table A.3 (cont.)				
Ripple effects		Individual stakeholders	Affected:individual	Citizens directly impacted by the hazard.
Ripple effects		Communities	Affected:community	Neighborhoods or stakeholder groups impacted by the hazard.
Ripple effects		Companies	Affected:company	Specific companies impacted by the hazard.
Ripple effects		Industries	Affected:industry	Entire industries impacted by the hazard (i.e. fishing charters or kayak tours).
Ripple effects		Technologies	Affected:technology	Technologies impacted by the hazard (historically polluting manufacturing work or dredging technology itself).
Ripple effects		Society	Affected:allsociety	Social impact beyond the local geographic scale (ie hazard event creating national dialogue on pollution, etc.)
Impacts		Government regulation	Impact:regulation	Increased or decreased government regulation of creation of or access to hazard.
Impacts		Change in sales	Impact:sales	Changes in sales due to hazard (lost business, or increase in sales of protective equipment, etc.)
Impacts		Financial consequences	Impact:finance	Changes in investments or property value, some parties made to pay damages.
Impacts		Legal action	Impact:legalaction	Litigation after discovery of hazard based on damages.
Impacts		Hazard exposure	Impact:hazardchange	Increase or decrease in people's exposure to the hazard through physical or behavioral changes (sediment remediation, avoidance of contaminated waterway)
Impacts		Community concern	Impact:commconcern	Fear, outrage, (or alternately satisfaction) on the community level.
Impacts		Change in confidence in institutions	Impact:institutionconfidence	Increased or decreased trust in managing agencies and organizations responsible for addressing hazard.
Change in risk message		Amplified	Risk:amplified	Perception of risk has increased.
Change in risk message		Attenuated	Risk:attenuated	Perception of risk has decreased.
Change in risk message		Neutral/uncertain/not applicable	Risk:n/a	Change in perceived risk cannot be determined by this statement, is ambiguous, or was not stated.
Other		Other	Other	Important concepts/potential new codes that nevertheless do not fit neatly into SARF categories, such as academia and social media.

APPENDIX B: IRB DOCUMENTATION

University of Illinois at Urbana–Champaign

Institutional Review Board Office
526 East Green Street, Suite 203, MC-419
Champaign, IL 61820
tel: 217-333-2670 fax: 217-333-0405
E-mail: irb@illinois.edu Web: www.irb.illinois.edu

CO-INVESTIGATORS & RESEARCH TEAM ATTACHMENT

IRB Number 14850

Responsible Project Investigator: Caitlin McCoy

Project Title:

Community Perceptions of Process and Benefits of Contaminated Sediment Remediation and Restoration in Areas of Concern

☐ Submitting with Initial IRB-1 Application
☒ Changing research team, date of submission 7/7/2014

List all investigators engaged in the research study, including those from other institutions. Include all persons who will be 1) directly responsible for the project's design or implementation, 2) recruitment, 3) obtain informed consent, 4) involved in data collection, data analysis, or follow-up.

Collaborators, outside consultants, and all graduate and undergraduate students should be listed if they will be responsible for these activities. Include all investigators named on grant proposals who will be engaged in human subjects research.

Note: Changes made to the Responsible Project Investigator require a revised IRB-1 application and amendment form.

Please copy and paste text fields to add additional researcher team members.

Last Name: Krupa		First Name: Mark		BS
Dept. or Unit: Illinois-Indiana Sea Grant		Office Address: 374 NSRC		Mail Code: 635
Street Address: 1101 W. Peabody Drive		City: Urbana	State: IL	Zip Code: 61801
Phone: 312-886-1430	Net ID: krupa3		E-mail: krupa3@illinois.edu	
Affiliation:	☐ UIUC ☐ Faculty ☒ Academic Professional/Staff ☐ Grad Student ☐ Undergrad Student ☐ Visiting Scholar, or ☐ Non-UIUC Affiliate of (Institution):			
Training	☒ CITI Training, Date of Completion, May 2014 ☐ Additional training, Date of Completion[1],			
☐	Please check box if this individual should be copied on IRB correspondence			

[1] Additional CITI modules may be required depending on subject populations or type of research. These include: (i) research enrolling children; (ii) research enrolling prisoners; (iii) FDA regulated research; (iv) data collected via the internet; (v) research conducted in public elementary/secondary schools; and, (vi) researchers conducted in international sites

Last Name: Lower		First Name: Erika		BS
Dept. or Unit: Illinois-Indiana Sea Grant		Office Address: 374 NSRC		Mail Code: 635
Street Address: 1101 W. Peabody Drive		City: Urbana	State: IL	Zip Code: 61801
Phone: 312-886-1430	Net ID: [redacted]		E-mail: elower@illinois.edu	
Affiliation:	☐ UIUC ☐ Faculty ☒ Academic Professional/Staff ☐ Grad Student ☐ Undergrad Student ☐ Visiting Scholar, or ☐ Non-UIUC Affiliate of (Institution):			
Training	☒ CITI Training, Date of Completion, May 2014 ☐ Additional training, Date of Completion[1],			
☐	Please check box if this individual should be copied on IRB correspondence			

APPENDIX C: SUPPLEMENTARY MATERIAL

C.1: Interview Questions from "Community Perceptions of Process and Benefits of Contaminated Sediment Remediation and Restoration in Areas of Concern"

1. What thoughts come to your mind when you think of the [AOC waterway]?

2. Are you active on the river (for recreation or work)? How often do you view/work on/recreate on (fishing, boating, wading, etc) the river?

3. What is the most important aspect of the river for you? What do you value the most about the river?

4. What are the biggest problems and threats currently facing the river?

5. Now I'm going to name some aspects of the river. Please tell me your thoughts about each aspect that I name.

- *a. Beauty of river*
- *b. River's effect on quality of life*
- *c. River's effect on property values*
- *d. Safety of river (fish consumption, waterfowl consumption, wading, family outings, environmentally…)*
- *e. A place for fish and wildlife to live and grow (habitat quality and amount)*
- *f. Depth of the river (Boat docking and access)*
- *g. River's effect on the local economy [business, tourism (charter fishing, boating)]*
- *h. Likeliness of new development along the river*

A number of large-scale remediation and restoration activities have taken place over the past decade and are currently taking place on the [AOC waterway].

6. How will your view of the river change after the remediation and restoration activities are complete?

7. What do you think will change the most as a result of the remediation and restoration?

8. Now we'll go through each of the aspects identified in past research. Please tell me how you think your view of the river will change for each aspect once remediation and restoration are complete.

- *a. Beauty of river*
- *b. River's effect on quality of life*
- *c. River's effect on property values*
- *d. Safety of river (fish consumption, waterfowl consumption, wading, family outings, environmentally…)*
- *e. A place for fish and wildlife to live and grow*
- *f. Depth of the river (Boat docking and access)*
- *g. River's effect on the local economy [business, tourism (charter fishing, boating)]*
- *h. Likeliness of new development along the river*

9. Awareness/Participation in Outreach Activities

- *a. Have you received any information regarding remediation and restoration activities on the river?*

i. IF YES, where did you receive the information (pamphlets/public meetings)? Was it easy to understand? Why?

b. Do you have a desire to be more informed about remediation and restoration activities?

i. IF YES… What is the best way to inform you about remediation and restoration activities (newspaper, door-door pamphlets, church bulletin, school announcements, website)?

c. Have you in any way been involved in the remediation and restoration activities? Why did you participate?

d. Have your expectations about the remediation and restoration been met so far?

10. Any suggestions on whom else I should talk to? Do you have any recommendations on whom to talk to about tracking changes in fishing, park use, or boating?

11. Is there anything else you'd like to say about the [AOC waterway] or EPA remediation and restoration in [AOC waterway]?