

**Assessing Aquatic Ecosystem Health Benefits Arising from Activities  
Associated with Community-Based Monitoring**

by

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## **Abstract**

In Canada, government funding cutbacks have decreased the capacity for government-sponsored water quality monitoring. In response, many community-based water monitoring (CBWM) organizations have been established that have undertaken the role of water monitoring and restoration. CBWM has the potential to aid in greater understanding of aquatic ecosystems and to assist in restoring ecosystems degraded by anthropogenic stressors; however, CBWM is often faced with challenges of credibility and capacity, and there is very little understand how, and if, CBWM benefits the ecosystems where they are established. To address this knowledge gap, my research utilizes a case study approach of 5 CBWM organizations within Atlantic Canada to identify and assess the potential ecosystem benefit of 15 different restoration projects. Using semi-structured interviews and photo-elicitation, my research looks at the planning, conducting, and follow-up of each projects and identifies cases where monitoring and restoration have led to benefits within aquatic ecosystems.



## **List of Abbreviations Used**

%EPT	Percent, Ephemeroptera, Plecoptera, and Trichoptera
CABIN	Canadian Aquatic Biomonitoring Network
CBM	Community-based Monitoring
CBWM	Community-based Water Monitoring
CEAA	Canadian Environmental Assessment Act
CURA	Community-University Research Alliance
SSHRC	Social Sciences and Humanities Council of Canada

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# Chapter 1: Introduction

## 1.1 Significance of Research

“Nowhere does the link between human health and the environment manifest itself more strongly than our reliance on fresh clean drinking water” (Davies & Mazumder, 2003, p. 273). Of earth’s water resources approximately 98% resides in oceans, a water source that is too saline for human consumption without treatment (Jury & Vaux, 2007); the remainder, 2% of earth’s water resources is freshwater (Shiklomanov, 1998).

Numerically, this is a substantial amount of water capable of sustaining the current human population, but most of this water is not readily available or easily accessed (Jury & Vaux, 2007). Approximately 69% of earth’s freshwater resides in glaciers and polar ice, and 30% exists as groundwater (Shiklomanov, 1998; Jury & Vaux, 2007). Less than 1% of earth’s freshwater resources is surface water, lakes and streams, and at present, this is the water readily available to support human, terrestrial, and freshwater life (Shiklomanov, 1998).

Throughout the course of history, humans have altered water flows, contaminated water sources (Davies & Mazumder, 2003; Dodds et al., 2013), and extracted vast amounts of water for agricultural, industrial, and public use. On a global scale, freshwater sources have been impacted by human activities to the extent that lakes and rivers existing in a natural state, unaffected by humans, are becoming scarce (Maddock, 1999). Throughout the world there has been a growing concern for the environment within the public sector (Allan, 2004), and many citizens have taken on the responsibility of environmental protection and stewardship (Whitelaw et al., 2003). Within Canada, public concern for the management and protection of water resources has led to substantial growth in community-based water monitoring (CBWM) organizations that have tasked themselves with monitoring aquatic ecosystems and reacting to issues of concern (Whitelaw et al., 2003), especially in light of reduced government monitoring in recent years (Pollock & Whitelaw, 2005; Sharpe & Conrad, 2006; Winegardner, Hodgson, & Davidson, 2015),

and a growing general lack of trust in government monitoring (Au et al., 2000). CBWM organizations often engage in restoration activities triggered by monitoring to mitigate anthropogenic impacts and improve aquatic ecosystem health, but despite the frequency and abundance of projects conducted by CBWM organizations there remains a gap in the academic literature regarding the benefit, *if any*, that such activities provide to the natural ecosystem (Conrad & Hilchey, 2011). Given this gap, the goal of my research is to identify cases where activities conducted by CBWM organizations have benefitted the aquatic ecosystems being monitored. To undertake this study, I drew on cases of CBWM from Atlantic Canada, but the findings have transferability within the field of CBWM.

## 1.2 Literature Review

### 1.2.1 Freshwater Resources at a Global Scale

For the first time in recorded history there is mounting concern that the mistreatment of freshwater resources, stemming from human consumption and pollution, will limit food production, ecosystem functions, and supply for future generations (Jury & Vaux, 2007; Vörösmarty et al., 2010). This mistreatment is not new, but the cumulative effect of “a long history of degradation through direct and indirect human influence” (Maddock, 1999, p. 373). Freshwater sources have been globally impacted by flow alteration, overexploitation, pollution, species extinction, species introduction, and destruction or degradation of habitat (e.g. Davies & Mazumder, 2003; Folke, 2003; Dudgeon, et al., 2006; Jury & Vaux, 2007; Vörösmarty et al., 2010; Dodds et al., 2013; Seidl & Stauffacher, 2013), to the extent that river and lake systems that exist in a natural state, unaffected by humans, were already considered a rare phenomenon 15 years ago (Maddock, 1999). Human impacts have led to the loss of ecosystem services<sup>1</sup> and aquatic biodiversity at a global scale (Gleick, 2003; Dudgeon et al., 2006; Dodds et al., 2013). Economically, this has major implications (Dodds et al., 2013). For example, nearly 20

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<sup>1</sup> The services or benefits that humans derived directly or indirectly from ecosystem functions; these services include “water processing, carbon sequestration, regulation of atmospheric gases, water regulation, climate regulation, genetic resources” and many additional services (Roni & Beechie, 2013, p.5).

years ago, a dollar figure was placed on freshwater ecosystems goods and services; Postel and Carpenter (1997) suggested several trillion dollars was generated annually, undoubtedly those numbers still hold if not having increased. From a socio-political and economic perspective, this can lead to increased stakeholder competition for water resources, and the escalation of serious conflicts in water scarce areas where water sources are shared over political boundaries (Poff et al., 2003; Dudgeon, et al., 2006). From an ecosystem perspective, increased demand will amplify the stress being placed on water sources and the loss of biodiversity will continue (Anderson, 2006; Dudgeon et al., 2006) as the growing human need for water will likely take socio-political precedent over biological water needs (Jury & Vaux, 2007).

The susceptibility of freshwater resources to anthropogenic impacts ties into the tight knit relationship between human society and its water needs, and the “disproportionate richness of inland waters as a habitat for plants and animals.” (Dudgeon et al., 2006, p. 164). Freshwater sources cover only a fraction of the earth’s surface, less than 1%, and are home to approximately 10% of all know species (Shiklomanov, 1998; Balian et al., 2008; Strayer & Dudgeon, 2010), they often support areas of high human population density (Vörösmarty et al., 2010), and are extensively used for resource extraction, agriculture, and industry. Lakes and rivers are products of their environment that extend far beyond the wetted perimeter of the water source, and include the entire catchment basin<sup>2</sup> where they reside (Allan, 2004). Their positioning within the catchment basin (normally at the bottom), makes lakes and rivers receptors for any wastes, sediments, or pollutants that can become mobilized by water runoff or transported though the groundwater table (Dudgeon et al., 2006). Additionally, water sources are susceptible to trans-boundary atmospheric pollutants (Vörösmarty et al., 2010) such as acid rain (see Clair et al., 2007). Management strategies often treat water as a resource that can “be extracted, diverted, contained or contaminated in ways that compromise its value as a habitat for organisms.” (Dudgeon et al., 2006, p.166). The combined impact of

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<sup>2</sup> “Water is delivered to each freshwater system from its catchment or drainage basin (watershed) – an area of land that collect precipitation and drains that water to a common point in the landscape or into another freshwater body” (Arthington, 2012, p. 35)

anthropogenic stressors placed on aquatic ecosystems has caused a dramatic decline in aquatic biodiversity (Sala et al., 2000; Jury & Vaux, 2007), with many species currently listed as threatened or extinct (Strayer & Dudgeon, 2010). Due to these factors, freshwater ecosystems have become one of the most endangered ecosystems in the world (Dudgeon et al., 2006). As Dudgeon et al. (2006) state, “if trends in human demands for water remain unaltered and species losses continue at current rates, the opportunity to conserve much of the remaining biodiversity in fresh water will vanish...” (p. 164).

Current water management strategies and treatment of waste created by human activities have been largely insufficient at preventing the pollution of surface water sources (Jury & Vaux, 2007). Establishing management strategies that promote a balance between human demand, water quality, and biodiversity must be developed. These strategies need to be based on a scientific understanding of aquatic ecosystem health, while considering social restraints and financial costs of altered and unaltered aquatic ecosystems (Davies & Mazumder, 2003). The time of living in an era where human influences on freshwater sources were minimal enough that ecosystems were able to self-repair seems to be over (Folke, 2003). Without human intervention, freshwater systems will continue to be polluted and degraded, causing the continual declines of aquatic ecosystem biodiversity and health.

### 1.2.2 Freshwater Resources in a Canadian Context

When it comes to freshwater resources, Canada is a water rich country. Canada holds approximately 9% of the world’s renewable freshwater resources, while having less than 1% of the world’s population (Trainer, 2010; Natural Resources Canada, 2012). Lakes and rivers cover roughly 12% of Canada’s landmass (Statistics Canada, 2010). Despite having an abundance of water, the vulnerability of Canada’s water supply has been exposed through high profile events of drinking water contamination such as in Walkerton, Ontario and North Battleford, Saskatchewan and “numerous boil water orders in other municipalities in Canada, have been stern reminders that we can’t take a healthy environment for granted” (Khan et al., 2003 p. 221). Biodiversity and water quality

within aquatic ecosystems are being impacted by the expansion of agriculture, industry, and urbanization (Davies & Mazumder, 2003; Chu et al., 2003), and there is growing evidence that continual expansion and climate change will further impact freshwater resources (Schindler, 2001; Trainer, 2010). As the population of Canada is estimated to grow by 8.1 million people within the next 25 years (Statistics Canada, 2009), expansion in at least one or more of the aspects identified will be unavoidable in order to accommodate growth.

In North America documentation of aquatic biodiversity has shown that extinction rates in freshwater species is approximately 4% per decade (Ricciardi & Rasmussen, 1999), and numerous freshwater fauna is listed as endangered (Naiman et al., 1995; Ricciardi & Rasmussen, 1999). Twenty-seven percent of freshwater species in North America are listed as endangered (Ricciardi & Rasmussen, 1999), and historically “*not a single aquatic species has been delisted through Endangered Species Act procedures because of implementation of a successful recovery plan...*” (Williams et al., 1989 as cited in Kauffman et al., 1997, p. 13; emphasis added). Currently in Canada there is a total of 176 aquatic species listed as at risk, and approximately 77% of them are species that require or live in freshwater habitats (Fisheries and Oceans Canada, 2015). Forty-five of the species listed are anadromous fish species that require freshwater systems for reproduction and juvenile rearing habitat (Fisheries and Oceans Canada, 2015).

In Canada it is predicted that water sources are going to be placed under greater stress in the future from continual population growth, resource extraction, industry, agriculture, and climate change (Trainer, 2010). Chu et al., (2003) modeled watersheds throughout Canada based on biodiversity, environmental conditions, and stress levels (based on industry and population pressure); their goal was to identify areas within Canada of high conservation priority based on fish species biodiversity. Findings indicated that watershed stress increased in a north-south gradient, being significantly higher in the southern portion of Canada, reflecting the population distribution within the country (Chu et al., 2003). Watersheds of the greatest concern were located in the southern regions of British Columbia, the Prairies, Ontario, and Quebec (Chu et al., 2003). In Chu et al.,

2015, the study was re-conducted with an updated dataset that showed increased stress on northern watersheds due to a warming climate. Watersheds with the greatest concern were located throughout British Columbia, the Maritimes, southern Ontario, and southern Quebec (Chu et al., 2015). This expansion could highlight future challenges to aquatic biodiversity in Canada, especially in watersheds in the Maritime Provinces that have been weakened by acidification (Clair et al., 2002; Clair et al., 2007).

When it comes to Canada's freshwater resources there is reason to be concerned, and knowledge gaps to be filled. Reviews of existing scientific literature identify that Canada's freshwater resources are "less secure than conventional views would suggest" (Bakker & Cook, 2011 p.275), and there is growing instances of water scarcity across the country as government, industry, and municipalities have been faced with water shortages caused by pollution, poor management, increased demand, and urbanization (Brandes, 2005). The current water management framework that permits and regulates withdrawals from water sources does so with little regard for ecosystem health at a watershed level (Brandes, 2005). Water in Canada is losing the protection that was constitutionally bestowed on it by legislation such as the *Canadian Environmental Assessment Act*, *Navigable Waters Act*, and *Fisheries Act*. Worse, changes to the *Canadian Fisheries Act* in 2012 removed the mandatory protection of fish habitat for all fish species that are not regarded as part of a commercial, recreational or Aboriginal fisheries, or that supports such a fishery (Hutchings & Post, 2013). This could potentially lead to the detriment of numerous aquatic species that are not specifically protected under the Act as habitat loss has a very strong correlation with species decline and extinction (Dudgeon et al., 2006). Another recent change to environmental legislature was the introduction of Bill C-45 in 2012, that amended the *Navigable Waters Protection Act, 1985* responsible for the protection of navigation on 40,000 lakes and over 2 million rivers within Canada (Kirchhoff & Tsuji, 2014). The amendment, removed protection from 99% of Canada's waterways only granting protection under the Act to 3 oceans, 94 lakes, and 62 rivers (Kirchhoff & Tsuji, 2014), meaning that a majority of development projects on Canada's waterways would no longer require an environmental assessment to be conducted (Winegardner et al., 2015). These changes were instated after an already



weakened or ‘streamlined’ version of the *Canadian Environment Assessment Act* (CEAA, 2012) was approved, which exempted many projects types from mandatory environmental assessment, and removed many of the triggers that would required an environmental assessments to be conducted in the past (Winegardner et al., 2015). Simultaneously occurring with these legislative changes the Canadian government approved a budget bill that drastically reduced the capacity of federal agencies to conduct environmental monitoring and research on inland waterways (Winegardner et al., 2015).

Previously, Canada has been regarded as a world leader in water governance, protection, and research due to government funded water monitoring and research programs that promoted collaboration between federal, provincial, and academic aquatic scientists (Schindler, 2001). That has changed; through ongoing budget cuts and legislation changes Canada is not able to sustain the quality of water monitoring that was supported in the past (Schindler, 2001). Many government departments no longer have the capacity to perform the water monitoring tasks that they were responsible for in the past, resulting in the fragmentation of monitoring data that is required to make informed decisions regarding Canada’s water resources and aquatic ecosystem health (Vaughan et al., 2003; Pollock & Whitelaw 2005; Sharpe & Conrad 2006; Kebo & Bunch, 2013). There appears to be a shifting dynamic towards a reliance on nongovernmental sources for environmental research and monitoring (Winegardner et al., 2015); the question of government trust in these data is an important one but beyond the scope of this study (for reading in this area, see Au et al., 2000; Whitelaw et al., 2003; Buckland-Nicks, 2015).

### 1.2.3 Community-Based Water Monitoring and Citizen Scientists

Public participation in environmental monitoring has the potential to aid in a greater understanding of the state of the environment (Conrad & Hilchey, 2011). Public involvement in environmental monitoring has seen substantial growth within Canada (Savan et al., 2003; Wieler, 2007; Pollock & Whitelaw, 2005), and at a global scale (Chicoine, 1996; Conrad & Hilchey, 2011). This growth has been attributed to a mounting environmental consciousness and concern for the environment within the

public sector (Allan, 2004), and increasing public understanding and concern regarding the anthropogenic degradation of natural ecosystems (Whitelaw et al., 2003; Conrad & Daoust, 2008). The emergence of public engagement in environmental monitoring coincides with an increase in CBWM organizations, a trend that has been documented throughout Canada (Savan et al., 2003; Whitelaw et al., 2003; Sharpe & Conrad, 2006; Conrad & Daoust, 2008), and globally (Darwall & Dulvy, 1996; Foster-Smith & Evans, 2002; Monk et al., 2008). Community-based monitoring (CBM) in general is defined as “a process where concerned citizens, government agencies, industry, academia, community groups and local institutions collaborate to monitor, track and respond to issues of common community concern” (Whitelaw et al., 2003, p. 410). It is often driven by the need to understand social and ecological factors that have the potential to affect one’s community, as “monitoring is a first step toward taking responsibility for the condition of one’s home, community, or ecosystem” (Bliss et al., 2001, p.145). Motives for establishing CBWM organizations vary: e.g. monitoring due to concern for a special place, to understand a perceived environmental problem or threat, or for the collection of baseline data in order to be able to track environmental change over time (Bliss et al., 2001). These examples are not exhaustive as organizations may choose to monitor for a variety of reasons and have multiple drivers that trigger the need for monitoring. With the diversity amongst organizations, mandates are designed to cater to the specific needs of the area where monitoring is being conducted and can include public education, habitat restoration, detection of environmental change, or establishment of baseline conditions (Savan et al., 2003; Conrad & Daoust 2008).

CBWM has been identified as a relatively new trend and it is still in its ‘infancy’ stage (Bliss et al., 2001), but community involvement in environmental monitoring has a long and successful history of being used in a variety of projects. The National Audubon Society’s Christmas Bird Count has engaged citizens to collect data on bird biodiversity over large geographic areas for over 110 years (Tulloch et al., 2013). In the 1970s, the Ontario Ministry of Environment trained and provided citizens in southern Ontario with supplies to collect samples and conduct routine water monitoring for 150 different lakes in its ‘cottage country’ (Stokes, Havas, & Brydges, 1990). The project was successful in

establishing monitoring trends for the 150 lakes, and allowed for the collection of data that was far beyond the capacity of what the Ministry could have conducted on its own (Stokes et al., 1990). Earthwatch, a not-for-profit environmental organization, has even developed its research and conservation model on the foundation of citizen science involvement (Hartman, 1997). Founded in 1972, Earthwatch has paired over 35,000 volunteers with scientific experts to help fund and conduct research on more than 1,500 projects, in over 100 countries (Hartman, 1997).

The emergence of CBWM highlights the democratization of science that enables citizens to participate in the generation of scientific knowledge (Carr, 2004; Pollock & Whitelaw, 2005; Carolan, 2006), which also strives to compensate for waning trust and capacity within government departments to conduct adequate environmental monitoring. CBWM organizations are actively participating in ‘citizen science’, a process where non-scientists take on the role of a scientist when conducting research (Tulloch, 2013; Johnson et al., 2014). In the traditional citizen/scientist relationship, citizens are used as a source for information or to aid in the collection of information, which is then analyzed and interpreted by the scientist (Conrad & Hilchey, 2011), such as in the Christmas Bird Count, lakes monitoring project, and Earthwatch projects. When acting in the role of a citizen scientist, however, the citizen becomes responsible for both the collection and interpretation of data (Conrad & Hilchey, 2011). Citizens are well positioned to actively pursue scientific research within their communities as they are often engaged in local issues, involved in community development, and in the position to have influence on local decision makers (Whitelaw, 2003; Pollock & Whitelaw, 2005).

#### 1.2.3.1 Community-Based Monitoring Structures

Just as the motives for the establishment of CBM organizations differ, there are also a variety of organizational structures. The literature identifies 4 main approaches to CBM: (1) government-led CBM; (2) interpretive monitoring; (3) advocacy monitoring; and (4) multiparty monitoring (Whitelaw et al., 2003; Pollock & Whitelaw, 2005). Government-led CBM is normally established as a way to detect ecosystem change, with the support of scientific experts (Stadel & Nelson, 1995). This is done by utilizing citizens to collect

long-term data sets that can be used both by government and CBM organizations to track any ecosystem changes that deviate from the established baseline conditions (Whitelaw et al., 2003). An interpretive approach focuses on public education through participation in monitoring (Whitelaw et al., 2003), as it seeks to expand the scientific focus of CBM programs by developing an understanding of the participants' motives for monitoring and knowledge, and then provides volunteers with relevant personal learning opportunities through first hand experience (Cuthill, 2000). Advocacy CBM focuses on gathering information on identified issues of concern to trigger action that can lead to positive environmental change (Sharpe, Savan, & Amott, 2000). CBM organizations involved in advocacy monitoring will focus their efforts in reaction to a current problem in order to have the issue addressed (Conrad & Daoust, 2010). Multiparty monitoring involves the collaboration of diverse groups of stakeholders to address environmental issues (Whitelaw et al., 2003); participants engage in monitoring that is designed to encompass the different values and perspectives of interested stakeholders (Bliss et al., 2001).

#### 1.2.3.2 Benefits and Challenges of CBWM and Citizen Science

There are many benefits attributed to CBWM and citizen science. Collaboration between stakeholders can build social capital within communities, while strengthening relationships between citizens, industry, and government (Bliss et al., 2001; Sharpe & Conrad, 2006; Conrad & Daoust, 2008). This can lead to greater scientific literacy within the community (Pollock & Whitelaw, 2005), and promote the creation of environmental stewardship initiatives, thus providing greater environmental protection (Whitelaw et al., 2003). Building local capacity and relationships between citizens and authorities can also lead to faster response times by authorities when citizens report issues of environmental concern (Danielsen et al., 2009). Governments can benefit by using citizen produced monitoring data to supplement their own data sets and expand on their monitoring networks (Stokes et al., 1990; Cuthill, 2000; Carr, 2004; Sharpe & Conrad, 2006). This is especially important in countries such as Canada where cutbacks in government monitoring has created fragmentation in data collection by Environment Canada and the Department of Fisheries and Oceans (Sharpe et al., 2000; Pollock & Whitelaw, 2005;

Sharpe & Conrad, 2006). CBWM can provide the capacity to monitor in some of these cases (Carr, 2004). CBWM provides governments with the opportunity to access monitoring data within remote areas where monitoring could not otherwise be conducted (Dyck, 2007), without a substantially increased monitoring budget (Carr, 2004). Local communities conducting monitoring have the capacity to provide early detection of environmental problems (Sharpe & Conrad, 2011), and extend monitoring protection as flexibility in schedules allows for work to be conducted outside of regular office hours (Stokes et al., 1990). Local community organizations are in the position to quickly respond to environmental issues, and provide a point of contact within the community where citizens can report environmental issues (Conrad, 2008). An example of this, highlighted in Conrad (2008), is where citizens in Lower Sackville, Nova Scotia, reported a strange odour and discoloration in the waterway to the local CBWM organization, the organization in turn was able to immediately respond and notify the appropriate regulatory authorities. Throughout the duration of what was later identified as an acid-metal spill, the CBWM organizations were able to collect water-quality monitoring data and provide this information to the regulatory authorities (Conrad, 2008).

Within the scientific community, however, the validity of data collected by citizen scientists and volunteers has often been doubted (Darwall & Dulvy, 1996; Monk et al., 2008). Habitually, this is due to a lack of standardized monitoring protocols and training, and fragmentation in the monitoring data collected caused by insufficient funding (Bliss et al., 2001; Sharpe & Conrad, 2006). Although conflicting, many studies have indicated that volunteer collected data can be of the same quality as expert-collected data (Engel & Voshell, 2002; Nicholson, Ryan & Hodgkin, 2002; Foster-Smith & Evans, 2003; Monk et al., 2008); these studies include biological, physical, and chemical water monitoring parameters. However, Monk et al. (2008) caution that for accuracy to be maintained, “stringent protocols must be in place to ensure that the data collected are of reputable quality” (p. 867). This concern is highlighted in Conrad and Daoust (2008), where 73% of CBWM organizations that participated in the study indicated that they did not use a specific monitoring protocol or standardized procedure to collect monitoring data. It is

noted that this is from a relatively small sample of eleven environmental stewardship organizations, but still emphasizes the challenge of the collection of reputable data.

CBWM organizations may also lack guidance or knowledge necessary to make meaningful decisions regarding ecosystem sustainability (Roni et al., 2002; Sharpe & Conrad, 2006). To aid in areas where knowledge is lacking, many CBWM organizations have formed partnerships with universities and government that help by providing guidance, training, and access to equipment and facilities (Savan et al., 2003; Conrad & Hilchey, 2011). This promotes the utilization of standardized sampling procedures, can lessen some of the financial burdens associated with monitoring, and fosters relationships that benefit CBWM organizations, academics, and government agencies. This can also aid in the creation of a feedback loop where academics and government can inform CBWM organizations about how the data they collect are being utilized. One of the major frustrations and challenges of CBWM organizations expressed early on has been the lack of feedback on how their monitoring efforts have contributed to planning, management, or ecosystem sustainability (Stadel & Nelson, 1995; Conrad & Daoust, 2008). This can lead to volunteer ‘burnout’ or feelings that monitoring efforts are conducted only for the sake of monitoring, and creating even greater challenges for volunteer based organizations to retain dedicated members (Stadel & Nelson, 1995; Conrad & Daoust, 2008). Furthermore, the lack of a comprehensive policy framework in most Canadian jurisdictions for other stakeholders to participate in CBWM-led initiatives means that the burden of monitoring often falls solely on CBWM organizations (Conrad & Daoust, 2008).

Many CBWM organizations have tasked themselves with the protection and improvement of aquatic ecosystems. With fewer resources in Canada being allocated to water quality monitoring within federal and provincial government departments, the increased need for volunteer, community, and private landowner participation has become evident (Bliss et al., 2001), highlighting the increasing necessity for CBWM organizations (Carr, 2004). Despite the frequency and abundance of CBWM organizations conducting monitoring and restoration, there remains a gap in academic

literature regarding the benefit, *if any*, that activities associated with CBWM provide to the natural ecosystem (Conrad & Hilchey, 2011).

#### 1.2.4 Monitoring and Restoration

To monitor, is “to watch, observe, or check, especially for a special purpose; to keep track of, regulate, or control the operation of” as defined in the *Webster’s New Collegiate Dictionary* (cited in Bliss et al., 2001 p. 142). Monitoring plays a crucial role in understanding aquatic ecosystems, and allows for the identification of changes, stressors, or impacts to the system. Legg and Nagy (2006) identify 3 main tasks of monitoring within conservation management, “to inform the conservationist when the system is departing from the desired state; to measure the success of management actions; and to detect the effects of perturbations and disturbances” (p. 194). Monitoring provides resource managers with vital information that allows for the improved management of natural resources, and consequently it is difficult to evaluate environmental responses to restoration projects without the collection of adequate monitoring data (Bash & Ryan, 2002; Stem et al., 2005). In regard to conservation and restoration, the need for the collection of monitoring data has become increasingly important because currently the lack of data collected on restoration projects is severely limiting our understanding of how to conduct successful restoration (Roni et al., 2002; Bond & Lake, 2003; Bernhardt et al., 2005; Wohl et al., 2005; Woolsey et al., 2007; Pander & Geist, 2013).

Ideally aquatic restoration projects should identify project goals and objectives, both biological and water quality (Dahm et al., 1995; Kondolf, 1995; Lake, 2001; Palmer et al., 2005; Jähnig et al., 2010), target causes of environmental degradation (Beechie, 2008), incorporate monitoring procedures that establish baseline conditions and pre-restoration conditions (Kondolf, 1995; Chapman, 1998; Lake, 2001; Palmer et al., 2005; Bernhardt & Palmer, 2011), and document ecosystem improvements through reporting (Lake, 2001; Nienhuis et al., 2002; Palmer et al., 2005; Pander & Geist, 2013).

Unfortunately this is rarely the case, and despite the immense amount of time, money, and resources allocated to restoration projects, few projects incorporate the monitoring

necessary to determine if the project was successful or not (Palmer et al., 2005; Feld et al. 2011, Pander & Geist, 2013). There are a multitude of reasons associated with this, but some of the major factors identified are lack of understanding, agreement, and funding. Among these factors, the most pressing issue is a lack of scientific understanding and knowledge of aquatic ecosystems (Graf, 2001; Wohl et al., 2005). Undoubtedly, freshwater aquatic ecosystems are complex; in riverine systems there are numerous relationships between physical and chemical processes, and how they influence biodiversity and habitat is not fully understood (Kondolf, 1995; Graf, 2001; Pess et al., 2003; Wohl et al., 2005). This is further complicated as riverine systems are unique, thus restoration success in one riverine system does not necessarily mean that the same project would be successful in another (Hilderbrand, Watts, & Randle, 2005). Amongst the scientific community there is agreement that restoration is important but there is a lack of agreement on what successful restoration constitutes, the processes required to achieve this goal, or monitoring criteria required to determine project success (Roni et al., 2002; Palmer et al., 2005). Very few restoration techniques have been thoroughly evaluated, causing large amounts of uncertainty as to their effectiveness within the scientific community (Reeves et al., 1991; Kondolf, 1995; Kauffman et al., 1997; Roni et al., 2002). Restoration projects also suffer from a lack of funds to incorporate a proper monitoring framework, as funding agencies tend to provide financial support for action-orientated projects but seldom provide monies allocated to monitoring (Kondolf, 1995; Wohl et al., 2005). Without set criteria for implementing successful restoration, and funding models that incorporate funds for pre- and post-project monitoring there is little incentive for practitioners to monitor and report on restoration outcomes (Palmer et al., 2005). Without being able to prove success, there is risk that public support for restoration projects will decline (Palmer et al., 2005).

Within the scientific literature there are some prominent criteria highlighted for restoration success: restoration projects are developed and implemented with clear goals and objectives (Dahm et al., 1995; Kondolf, 1995; Lake, 2001; Palmer et al., 2005; Jähnig et al., 2010); monitoring data is collected both pre- and post-restoration that can be compared and contrasted (Kondolf, 1995; Chapman, 1998; Lake, 2001; Palmer et al.,



2005; Bernhardt & Palmer, 2011); and projects are documented with reports being made publically available (Lake, 2001; Nienhuis et al., 2002; Palmer et al., 2005; Pander & Geist, 2013). Projects that utilize these steps are not guaranteed to be successful but they will provide a basis for restoration projects to be evaluated, allowing for the advancement of restoration science. Also, large-scale restoration projects have been identified to have a higher chance of success, but are often not economically or socially feasible due to the availability of resources and conflicts of interest (Shields et al., 2003; Lake, Bond, & Reich, 2007). In these instances small-scale restoration has proved effective at targeting specific problems (Lake et al., 2007). Currently there is an abundance of knowledge on anthropogenic impacts that affect aquatic ecosystem biodiversity, habitat, and water quality. Many studies suggest that by targeting these specific impacts we can prevent further ecosystem harm and allow for natural restoration within the system (Kauffman et al., 1997; Jähnig et al., 2010; Ruwanza et al., 2013). This can allow for projects to be prioritized from a hierarchical approach based on the “probability of success, response time, and longevity” (Beechie et al., 2008, p. 892). Beechie et al. (2008) highlight 3 steps in prioritizing restoration actions based on Roni et al. (2003, 2008) ‘hierarchical approach’ to identify restoration techniques that have a high success rate, quick response time, and endure over the long term. First and foremost should be the protection of high-quality habitats, as habitat protection is much easier and provides greater ecosystem benefit than attempting to restore degraded habitat (Kauffman et al., 1997; Roni 2002; Beechie et al., 2008); second, restoration action should be focused on the reconnecting of isolated habitats (Beechie et al., 2008; Roni et al., 2008); and third, restoring should focus on processes that create and sustain habitat (e.g. streamflow, water quality, sedimentation, and riparian zone health) (Beechie et al., 2000; Bohn & Kershner, 2002; Roni, 2002; Beechie, 2008). An understanding of our freshwater resources in Canada is crucial to facilitate the implementation of management strategies that allow for the coexistence of multiple stakeholder groups and a healthy environment.

## 1.3 Project Overview

With government funding cutbacks that decrease Canada's government capacity to monitor and track environmental changes (Pollock & Whitelaw, 2005; Winegardner et al., 2015), and legislative changes that weaken the protection of freshwater resources (Hutchings & Post, 2013; Kirchhoff & Tsuji, 2014; Winegardner et al., 2015), the growing need for public involvement in water monitoring and management is evident. CBWM organizations have the ability to monitor and track changes within freshwater aquatic environments and aid in the prevention, mitigation, and restoration of anthropogenic impacts that threaten aquatic ecosystem health. In light of this, a more robust understanding of the benefits, *if any*, CBWM organizations provide to aquatic ecosystems through monitoring and restoration actions is needed (Conrad & Hilchey, 2011). Thus, in the research for my thesis, working with CBWM organizations, a multiple case study approach was used to identify, compare, and contrast cases where CBWM has influenced benefits to the ecosystems that they monitor (Conrad & Hilchey, 2011).

### 1.3.1 Research Questions and Objectives

My research has been guided by 3 main research questions:

1. Are CBWM organizations conducting activities that lead to observable or measurable improvements within the aquatic ecosystem that are being monitoring?
2. If so, what are these activities and how are they being implemented?
3. Is the photo-elicitation methodology capable of assessing restoration projects, and what are the strengths and weaknesses of this application?

In order to answer these questions, 5 critical research objectives were identified:

1. Identify and document actions conducted by CBWM organization resulting from monitoring that have the potential to benefit the natural ecosystem;
2. Obtain in-depth information regarding the planning, implementation, and follow-up stages of the actions identified to use for data analysis;
3. Identify cases where monitoring and restoration activities have led to positive observable or measurable ecosystems responses;
4. Identify the factors that enable success, and challenges that impede success; and
5. Evaluate the photo-elicitation methodology to determine if it is an appropriate methodology to use for the assessment of restoration projects.

Objectives 1 and 2 allow for the identification and collection of information on activities that have the potential to lead to measurable or observable improvements within aquatic ecosystems (research questions 1 and 2). Objective 3 allows for the identification of activities that show observable or measurable improvements, and how these activities are being implemented (research question 2). Objective 4 allows for the assessment of the strengths and weakness of each application and identify the factors that enable successful implementation of restoration projects and the factors that impede them (research question 2). And objective 5 allows for the assessment of the photo-elicitation methodology and its ability to assess restoration project (research question 3).

### 1.3.2 CURA H2O

My research contributes to a large 5 year Social Sciences and Humanities Research Council of Canada (SSHRC) funded project under a program called “Community-University Research Alliance” (CURA). This particular CURA project (2012-2016) is for community-based integrated water monitoring and management in Nova Scotia (see <http://curah2o.com>). The CURA H2O project provides a collaborative network where citizen groups and academics work together to develop standardized data collection methods and provide academic guidance to CBM groups. The CURA H2O project seeks

to increase community capacity for integrated water monitoring and management in Canada and abroad. CURA H2O utilizes the principle of an interdependent community that is dependent on partnerships between multiple stakeholders including government, non-government organizations, schools, the agricultural sector, academia, and community-based water stewardship organizations.

## **1.4 Organization of Thesis**

My thesis follows a manuscript-based format and is divided into 5 chapters. Chapter 1 provides an overview of the thesis, research questions and objectives, and a review of the literature used to inform the research. Chapter 2 provides a detailed description of the methodological approach used for data collection and analysis in the research process. Chapters 3 and 4 have been prepared as stand-alone manuscripts that will be submitted for peer-review publication. Specifically, Chapter 3 focuses on activities conducted by CBWM organizations and their impact on aquatic ecosystem health. Chapter 4 is a methodological paper that focuses on the approach employed to conduct this research. This is an important contribution as the methodology is unique for assessing environment-based projects in the capacity presented in the thesis. The conclusion, Chapter 5, synthesizes the research findings in relation to research objectives, identifies its contributions, and discusses the study's limitations and recommendations for CBWM organizations, government, and academics as well as recommendations for future research opportunities.

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## **Chapter 2: Methods**

### **2.1 Significance of Research**

As stated in the previous chapter, the goal of my research was to identify cases where activities conducted by CBWM organizations have benefitted the aquatic ecosystems being monitored. To undertake this study, I utilized a qualitative case study approach in which I document instances where CBWM actions have led to improvements within aquatic environments. This chapter covers the details of my study design, ethical considerations, recruitment process, data collection, and data analysis.

### **2.2 Study Design**

A qualitative multi-case-study approach was used to examine the relationship between CBWM organizations and the impacts of their activities on the aquatic ecosystems that they monitor. My study worked with 5 CBWM organizations within Atlantic Canada, with the participation of 8 individuals from within these organizations. A multi-case-study approach provided the potential to examine different cases of a similar nature to understand the similarities and differences between them (Baxter & Jack, 2008). The collection of data from multiple sources allows for this data to be amalgamated into the analysis process instead of handled separately; this amalgamation adds strength to the findings as it builds a more robust understanding of the case being studied (Baxter & Jack, 2008).

My study utilized a two-phased approach to collect data from key informants within CBWM organizations to identify and examine activities conducted to improve, maintain, or protect aquatic environments. My study design allowed, first, for the identification of activities that have the potential to impact the aquatic ecosystem, and second, for an in-depth inquiry into each of the activities identified that focused on the planning, conducting, follow-up, and end result of each activity. Utilizing inductive and deductive thematic data analysis, emergent observable and measurable ecosystem benefits were

identified and correlated with each project type. Project specific monitoring data was used when available to verify instances of measurable environmental improvement.

### **2.3 Ethical Considerations**

My study was approved by the Dalhousie University Social Science and Humanities Research Ethics Board, and the Saint Mary's University Research Ethics Board (Appendix A & B). Participants were not asked to perform any tasks outside of their everyday work scope and the information requested of participants is of low risk, as defined under the 2010 Tri-Council Policy Statement *Ethical Conduct for Research Involving Humans* (TCPS2), to both the participant and their respective CBWM organizations.

Throughout my study, steps were taken to ensure that research was being conducted in an ethical manner. Informed consent was obtained from all participants prior to conducting research (Appendix C), and participants were provided with an information letter that outlined the purpose of the study (Appendix D). Participants were also informed that they could withdraw from the study if they chose, and provided with instructions on how to withdraw. No participants chose to withdraw from the study. After interviews were conducted all identifying material was removed from the interview transcripts to ensure anonymity; although, given the small and tight knit cohort of CBWM organizations within the study region it was noted in the consenting process that there was a possibility that participants could be identified. Participants were given a copy of the interview transcript to confirm accuracy, a process known as transcript verification (Miles & Huberman, 1994). As the process of transcription involves a form of translation, it is possible that contextual meanings and nuances may be lost or misinterpreted in the process (Gibson, 2009). To address this, participants were provided with the quotations that were used in the final report, identification of where the quotation could be found in the interview transcript, and the context the quotation was being used in to ensure that they were not being misrepresented within the research.

## 2.4 Recruitment

### 2.4.1 Recruitment of CBWM Organizations

Through consultation with the CURA H2O research team, potential CBWM organizations were identified using a purposeful sampling methodology. Purposeful sampling ensured that the CBWM organizations that were contacted had a high potential to provide the information being sought by the study (Patton, 2002; Tracy, 2013). An ‘inclusion criteria’ list was developed, and used to narrow down the number of organizations that were contacted, the details of which are provided below.

Inclusion criteria for CBWM organizations:

1. Currently participating in the CURA H2O project;
2. Are a CBWM group that has been established for a minimum of six years (to ensure the potential for observable outcomes of any monitoring activities) (Leach, Pelkey, & Sabatier, 2002);
3. Retention of members who are knowledgeable of historical and current activities of the CBM organization;
4. Maintenance of supplementary records of activities conducted, such as historical photographs and journal logs;
5. Have conducted ongoing monitoring throughout this timeframe and retain records of the data (e.g., water monitoring, habitat assessment, fish surveys).

In total, 8 organizations fit these criteria. Each organization was contacted by email and provided with a recruitment package that explained the purpose of the research study (Appendix E). Following the email, each organization was contacted by phone within a one-week timeframe (Appendix F). In total, 5 CBWM organizations expressed interest in participating in my research; I requested for these groups to identify key informants within their organization that would be willing to participate in my study.

#### 2.4.2 Recruitment of Key Informants

Key informants are defined as people who have in-depth knowledge about a particular phenomenon (McKenna, Iwasaki & Main, 2011); in my study key informants were individuals who had in-depth knowledge about their CBWM organization, that were actively involved in the planning and decision making within the organization. Key informants were selected based on self-identification, group identification, and identification by the CURA H2O research team. A key informant should be exposed to the information required on a regular basis, have access to the information, and be willing to share the information and knowledge with the researcher (Whiting, 2008; McKenna et al., 2011; Stewart & Cash, 2011). Due to the level of information sought the key informant had to be a primary source of information, and directly involved with the information being provided (Stewart & Cash, 2011). Key informants were asked to verify that their CBWM organization matched the inclusion criteria, that they were willing to participate, and that they fit the key informant criteria before moving forward with my research.

Selection criteria for key informants:

1. The individual was self-identified, group-identified, or identified by the CURA H2O research team as able to provide the information required;
2. The individual was a willing participant;
3. They were involved in the planning, organization, and implementation of CBM activities;
4. They had in-depth knowledge of the past and present activities that their CBM organization conducts, and could explain the process from start (planning) to finish (follow-up);
5. They were a primary source of information, that is, someone who is directly involved with the information being provided (Stewart & Cash, 2011).



### 2.4.3 Informed Consent Process

All key informants who expressed interest in participating in my study were provided with an information sheet and informed consent form that described the nature of the study and how data would be collected and used (Appendix D & C). Key informants were assured that their participation was completely voluntary, and that they could withdraw from the study at any point up until preliminary data analysis. If and when a participant did choose to withdraw, I would exclude the data provided from the participant from my research. Written informed consent was obtained from all participants prior to conducting any research.

### 2.4.4 Description of Recruited Organizations and Participants

Research participants were members of CBWM organizations from Nova Scotia (3), New Brunswick (1), and Prince Edward Island (1) that are partnered in the CURA H2O project. These organizations are not-for profit and operate on a limited budget, often with only the capacity to hire a limited amount of full-time staff. The CBWM organizations that participated in this study had staff numbers ranging from 2 to 7 full-time staff. During the summer these organizations were able to hire summer students through grant funding. They also relied heavily on volunteers.

These organizations have been established in watersheds where anthropogenic stressors have impacted water quality and biodiversity; as a result these organizations have committed themselves to enhancing the ecological health of their watersheds through science, leadership, and community engagement. Each of the participating CBWM organizations is actively conducting water monitoring and restoration actions within their watersheds.

## 2.5 Data Collection

Primary data collection was conducted in 2 phases: semi-structured interviews and photo-elicitation interviews; additionally, water monitoring data for the projects was requested when available. The following section discusses the data collection methods and how they relate to the research. The progression of data collection phases was as follows: Phase 1 – semi-structured interviews; Phase 2 – photo-elicitation interviews; then, requesting water monitoring data. Data were collected in this order, as each phase was a natural progression of the previous phase of research.

### 2.5.1 Phase 1, Semi-Structured Interviews

Interview questions were structured into 3 sections: introductory, exploratory, and participant driven, following an ‘hourglass sequence’; interviews started with broad open-ended questions that became more focused as the interview progressed, then concluded with an open-ended section where the interview became participant driven (Stewart & Cash, 2011). Interviews were used to collect general information about each CBWM organizations, to verify the selection of key informants, and to identify actions conducted by each organization to use in Phase 2.

The introductory section of the interview was structured predominantly around questions designed to lead to open-ended discussion (Harvey-Jordan & Long, 2001; Whiting, 2008). The introduction targeted information regarding the interviewee such as: the level of engagement in the organization, length of time working with the organization, and current role within the organization; it also targeted general information regarding the CBWM organization such as the reason why it was established, the mandate, and future goals of the organization. The second part of the interview used structured questions to identify the different activities conducted by the organization that would be examined in-depth in the photo-elicitation research phase. The exploratory section asked questions regarding: environmental problems that have been encountered in relation to the aquatic ecosystem; how these problems can be assessed in the context of monitoring; the

activities that were conducted to prevent or mitigate the problems identified; and the general planning procedure for each of the activities. Based on the interview discussion, participants were asked to identify activities that they felt would be suitable to examine in-depth for the second research phase. The final section of the interview was participant driven. Participants were given the opportunity to discuss subjects they felt were relevant to the interview but were not addressed by the questions (see Appendix G for the Interview Guide).

### 2.5.2 Phase 2, Photo-Elicitation Interviews

The second research phase utilized a modified photo-elicitation methodology that involved using photographs as a visual aid in the interview process (Harper, 2002). First utilized by Collier (1957), the methodology showed an aptitude for standardizing research criteria, and facilitating in-depth responses to questions during interviews (Harper, 2002). The photo-elicitation methodology has developed into 2 primary variations. In the first, externally-driven photo-elicitation, the researcher controls and selects the visual imagery that is used in the interview process (Van Auken, Frisvoll, & Stewart, 2010). In the second, participant-driven photo-elicitation, the participants choose the visual imagery that is used in the interview process (Van Auken et al., 2010). The methodology used in this research has been modified to incorporate aspects from both externally-driven, and participant driven-methodologies; that is, I framed the context of the subject matter and used Phase 1 interviews to identify topics that could potentially be used for photo-elicitation, but the participant remained responsible for the identification of the topic and the selection of the photographs that were used in the interview process.

Activities that had the potential to impact aquatic ecosystem health were identified from the Phase 1 interview and presented to the participant(s) (Appendix – H). These activities were used as suggested topics to explore during the photo-elicitation interview, and participants were requested to select 3 to 5 activities that fit the research criteria. Participants were not limited to selecting from activities that were identified in the first interview and were encouraged to include alternate activities that they felt matched the

provided criteria. Once the activities were chosen participants were given 2 weeks to organize the photographs. Photographs were provided 1 week prior to the scheduled interview date so that photographs could be organized and printed, and so that I could study them to help develop my line of questions to the participants.

The photo-elicitation interview was conducted in person using a structured interview guide to discuss the planning, conducting, following-up, and outcome of each activity (Appendix I). The guide was developed to facilitate open-ended conversation and to ensure that specific information necessary for the study was obtained during the interview. Many of the sections used one overlying open-ended question, but then relied on checkbox questions or prompts to ensure that all information was covered. If the participant answered a checkbox question during their answer the box was marked and the question was not directly asked. If not, the question was directly posed to the participant. This method of interviewing provided a fluid interview process with minimal interruption from the researcher, allowing for the process of the activity to be captured in full (Weiss, 2004).

The first section of the interview was structured to gain general knowledge regarding the activity type, the location where the activity was conducted, and the reason that it was conducted. The following sections focused on the planning, conducting, and following-up for each activity using pictures to facilitate in-depth conversation regarding each of these phases. The final section allowed for the participant to speak freely about anything relevant to the subject matter that was not covered by the questions. This process was completed for each individual activity discussed during the photo-elicitation interview.

### 2.5.3 Recording Data

Both Phase 1 and Phase 2 interviews were digitally recorded and transcribed verbatim by me following the interview. I then read along with the transcript as the audio recording played and corrected the transcript to ensure quality, a process known as fact checking (Tracy, 2013). Participants were given the option to review the transcription of their

interview to check for accuracy (Baxter & Eyles, 1997). Transcriptions were provided to participants by e-mail, and participants were allotted a two-week period to review them to ensure the transcript quality. Participants were also given the option to request additional time to review transcripts; none of the participants requested additional time, and no significant changes to the transcripts were requested.

#### 2.5.4 Confidentiality

Due to the nature of the research and participants being selected from a relatively small cohort of CBWM organizations, anonymity of participants could not be provided. This was stated in the information letter provided to each participant (Appendix D). However, over the course of the study, every effort was made to ensure that identifying information was not made available beyond my thesis supervisor and myself.

The recorded data from all interviews was immediately transferred to a password-protected computer and files on the digital recorder were deleted. Participant codes were assigned to each file so that the data were not directly traceable to the organization or participant. The master code sheet with identifying information was stored in a different location than the interview data, and was only accessible by my thesis supervisor and myself. In all transcriptions identifying information was removed and participants were assigned anonymous identifiers throughout the document. All place identifiers that linked the organization and individual to the interview were also omitted from the text.

Copies of the data were provided to my thesis supervisor, to be held in safe electronic storage at Dalhousie University.

## 2.6 Data Analysis

Interview data were analyzed using qualitative coding, a process that uses the grouping of themes by topic in order to generate new ideas regarding the data (Richards, 2005). This approach, categorizing coded data based on patterns that are evident within the dataset

and then comparing them to themes relating to the study purpose and existing literature, is common in qualitative research (Aronson, 1994). The categories must be inclusive (i.e. reflecting a range of content in data); useful (i.e. meaningfully connected to data); mutually exclusive (i.e., separate and independent); and clear and specific (Marshall & Rossman, 1995). The purpose of qualitative coding is to identify and understand patterns and relationships with the data (Richards, 2005; Tracy, 2013). A combination of deductive and inductive thematic analysis was used to analyze commonalities, differences, and relationships of topics identified within the interview transcriptions (Gibson, 2009; Willig, 2013). In this process it is the responsibility of the researcher to define what the identified themes represent (Willig, 2013). Throughout the process each theme was defined and documented, and definitions were continually updated as themes were redefined and updated (Richards, 2005). All coding was done in NVivo 10™, a computer based qualitative data management tool.

During the transcription of Phase 1 interviews, a code list was developed that identified existing *a priori* codes of topics that were generated during the literature review, and in consultation with the CURA H2O research group (Gibson, 2009; Willig, 2013). Some of the codes from my start list included: activities conducted by CBWM organizations, organizational info, regulatory involvement, and environmental monitoring. This code list was applied in a deductive approach where transcriptions were read line for line and themes were grouped under the pre-determined codes (Crabtree & Miller, 1999). To insure the quality of *a priori* codes, these codes had to be represented throughout the interviews (Gibson, 2009). During the reading of the transcript additional emergent themes were identified that did not fall under any of the *a priori* codes. A secondary round of coding using an inductive approach was used to code the newly emergent themes (Tracy, 2013). For this, I reread the interviews line for line and identified and coded emergent themes that occurred and could be related (Kardorff, 2004). To help keep track of the *a priori* and emergent codes, a code list was maintained and updated that listed and defined each code (Tracy, 2013). When coding of all Phase 1 interviews was completed, top-level codes that focused on broad categories were identified and classified as parent codes (Gibson, 2009). Sub-codes, referred to as child codes, that existed under a

commonly themed parent code were then classified under the corresponding code. This method is referred to as the creation of a coding tree as a broad topic will branch out into its more specific sub-themes (Gibson, 2009).

Based on the parent codes identified during the Phase 1 interview analysis, a code list was developed for the Phase 2 interviews. This list was used for the first round of coding in the Phase 2 interviews. During the second round of coding existing child codes were inputted into the data set. At the same time the process of inductive coding was used to identify new emergent codes within the Phase 2 interviews. Once coding was completed, codes were organized ensuring that child codes were categorized under the appropriate parent codes. Related codes were merged to prevent redundancy in the analysis and identification of themes.

The photo-elicitation methodology was evaluated using personal reflection and evaluation based on Pauwels, 2010, 'integrated framework' for visual research. As the research questions are shaped by the analytical focus of the research (Pauwels, 2010), the evaluation focused on the adaptation of photo-elicitation and its ability answer the primary research questions. Evaluation assessed the quality of information generated by pairing photographs with semi-structured interviews (Kong et al., 2015), and the ability of the photographs provided to visually depict the restoration activities that were conducted (Rose, 2001; Kong et al., 2015). The quality of information provided by the methodology was based on its ability to answer the primary research questions.

## **2.7 Positionality Statement**

I became interested in undertaking this study for a number of reasons – not just the ones that will be discussed in my thesis with respect to filling a gap in the literature. For the first part of my life that I can remember I lived on Vancouver Island, B. C. I was often outside, and always inquisitive about nature. I consider myself fortunate, as my family would often go on camping trips, hikes, and fishing trips. I was taught by my parents to be respectful and considerate of nature regardless of how small or insignificant it may

seem sometimes. Looking back, a common factor to many of my outdoor experiences was water. Whenever my family camped or hiked it would include a beautifully pristine lake, river, or waterfall, with water so clean that you could drink it without even giving it a second thought. That changed when I moved to the city in Ontario. Although, we lived next to a river it was not advisable to drink out of it and there were fish consumption warnings due to pollutants in the water. I had never even heard of something like this before. While living in Ontario my family stopped fishing and camping, not due to concerns over pollution or anything like that, just a change in lifestyle. I lost a lot of my connection with nature, and for the four years I lived there I had an ‘average’ suburban upbringing. My family eventually moved back to B. C. where I lived in a small town in the East Kootenays until I completed high school.

After completing high school, I moved to Calgary Alberta where I worked in the oil and gas sector for 3 years where I was often away from home for a majority of the time. Being dissatisfied with this lifestyle I sought work closer to home and started a career in the office moving and installation industry, where I worked from an entry level laborer to the position of lead supervisor. Always being interested in attending university, during this timeframe I attended upgrade courses at Mount Royal College in order to meet the entry criteria to the Environmental Science program that they offered. I still had an affinity for animals, nature, and the environment and I saw this as a good opportunity to align my work path with my personal interests. In 2008, I was accepted to the Environmental Science program at Mount Royal University, formerly college, where I completed the three-year course and received my Bachelor of Applied Science in Industrial Ecology. Throughout the program I developed a multitude of skills relating to environmental assessment of both terrestrial and aquatic systems. I took special interest in one course, aquatic ecology, where a field component had the class conduct a fish survey and habitat assessment on one of the local streams. This course showed me the possibility for my personal interests and academic training to develop into my future work. During my program I was also required to complete two work terms during the summer breaks. The first was with the City of Calgary’s Water Quality Monitoring division, where I was responsible for the collection of samples and data analysis of water



collected from designated points within the storm drainage system and Bow River. I learned the correct procedures for water quality sampling and how to interpret analytical laboratory results. The second work term was with a third party liability company that specialized in oilfield drilling, reclamation, and remediation work. I worked in the reclamation and remediation division in a position that then transferred into a full time job, where I worked for one year reporting on various stages of site reclamation, and analyzing lab results for soil and water samples. During my time in Calgary I began to reconnect with nature and would often spend my free time hiking, fishing, and camping, often combining the three together.

In 2012, I was accepted to Dalhousie University's Master of Environmental Studies program and relocated to Halifax, Nova Scotia. Through my original thesis proposal indicating that I was interested in working with water quality and aquatic ecosystem health, I was put in touch with my soon to be thesis supervisor Dr. Heather Castleden. Through discussions with Dr. Castleden I was introduced to her research colleague, Dr. Cathy Conrad, the lead investigator on the CURA H2O research project. There was an opening for a graduate student to study CBWM and its relation to the aquatic environment, which I accepted. During my time in Halifax I volunteered with a local community-based water monitoring organization. I did this because I was interested in being involved in my topic of research in the capacity of a volunteer, and because I believe in the work that they do. During my time there, I was not involved in any organizational planning or decision-making; my contribution was that of physical labour.

I pursued this research because in my future career I want to work with freshwater ecosystems, and this gave me the opportunity to work with CBWM organizations that were engaged in this line of work.

## **2.8 Summary**

This chapter has described the methods used throughout my research, from design to data collection and analysis. This chapter highlights the rationale for decisions made regarding

the research process, and the ethical considerations and procedures that were used to ensure ethical and fair treatment of participants throughout the process.

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# **Chapter 3: Does Community-Based Water Monitoring and Restoration Lead to Benefits Within Aquatic Ecosystems? Looking at Activities Conducted by Water Monitoring Organizations in Relation to Environmental Improvement**

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## **3.1 Statement of Student Contribution**

C. Garda was responsible for all data collection and analysis, which this manuscript is based upon, as well as writing all sections. H. Castleden provided supervision for all stages of research and contributed to writing development and manuscript revisions.

## **3.2 Abstract**

In Canada, environmental monitoring has largely been the responsibility of the government, but cutbacks in funding have left many government departments unable to do so. This has stimulated a rise in community-based water monitoring (CBWM) organizations throughout Canada that have tasked themselves with monitoring aquatic ecosystems. Additionally these organizations often engage in restoration projects stemming from their monitoring. Despite the growing abundance of CBWM organizations within Canada, there is uncertainty whether their existence leads to benefits within the aquatic ecosystems being monitored. A comprehensive analysis of qualitative interview data was employed to examine restoration projects conducted by 5 CBWM organizations, and their potential affect on aquatic ecosystems. Findings show that while

CBWM organizations are actively conducting projects that show physical change that is indicative of ecosystem improvement, examples of measurable responses within aquatic ecosystems remain rare. This research helps identify the factors that contribute to successful restoration and the factors that impede the restoration process.

### **3.3 Introduction**

Freshwater environments are some of the most threatened ecosystems in the world (Richter et al., 1997; Malmqvist & Rundle, 2002; Dudgeon et al., 2006; Chapman et al., 2014). Aquatic ecosystems are exposed to increasing and unprecedented threats from anthropogenic stressors that degrade water quality, destroy habitat, and harm the aquatic life (Karr et al., 1985; Harper et al., 1998; Bond & Lake, 2003; Dudgeon et al., 2006; Litvan, Stewart, Pierce, & Larson, 2008; Miller, Budy, & Schmidt, 2010). Although the causes of these threats are often known (e.g. pollution, flow regulation, overexploitation, drainage basin alteration, and invasive species), this knowledge has done little to mitigate or eliminate them and it is commonly accepted that the human use of ecosystem goods and services will come at a cost to biodiversity and water quality (Dudgeon et al., 2006; Dudgeon, 2014). If the degradation of freshwater sources continues at the current rate the chance to conserve these systems may vanish along with many of the species that depend upon them (Dudgeon et al., 2006; Dudgeon, 2014). In order to preserve freshwater sources there must be an understanding of the complex interactions between human activities and aquatic ecosystem health (Pander & Geist, 2013). Water monitoring provides a way to understand these interactions and assess the state of aquatic ecosystems to determine if they are vulnerable to harm (Bliss et al., 2001).

In Canada, environmental monitoring has historically been the responsibility of the government, but declines in funding have left many departments unable to do so, resulting in the fragmentation of monitoring data (Vaughan et al., 2003; Pollock & Whitelaw 2005; Sharpe & Conrad 2006; Kebo & Bunch, 2013). This is especially prevalent within water monitoring, and it inhibits Canada's ability to collect the data necessary for making informed decisions regarding water quality and aquatic ecosystem

health (Sharpe & Conrad, 2006; Conrad & Daoust, 2008). As government-run water monitoring programs have declined, community-based water monitoring organizations have become more prevalent throughout Canada (Conrad & Daoust, 2008). These organizations have ‘adopted’ watersheds and tasked themselves with conducting water monitoring, public education, mitigation, and restoration work within them. The purpose of this paper is to examine whether CBWM and activities associated with it lead to benefits within the aquatic ecosystems being monitored. This paper specifically looks at cases where CBWM organizations have conducted restoration activities within their watersheds, and the cause and effect of these actions.

### **3.4 Community-Based Water Monitoring in Canada**

Community-based monitoring (CBM) is “a process where concerned citizens, government agencies, industry, academia, community groups, and local institutions collaborate to monitor, track, and respond to issues of common community concern” (Whitelaw et al., 2003, p. 410). CBWM organizations actively participate in ‘citizen science’, a process where a non-professional scientist takes on the role of a volunteer scientist in conducting scientific research (Tulloch, 2013; Johnson et al., 2014), and ‘community science’, the interaction of community, agency, and industry, in generating new scientific knowledge (Carr, 2004). These organizations often exist in watersheds where human activities have impacted or have the potential to negatively impact the aquatic environment. CBWM organizations conduct monitoring throughout these watersheds and in many, if not most, circumstances, use the information collected to guide restoration, mitigation, and enhancement projects.

CBWM often faces challenges regarding credibility, capacity, and funding (Whitelaw, 2003; Sharpe & Conrad, 2006; Kebo & Bunch, 2013). The validity and methods of data collected by citizen scientists is often questioned by the academic community, professionally-trained scientists, and government agencies (Darwall & Dulvy, 1996; Monk et al., 2008). This can partially be credited to a lack of stringent sampling protocols and training, and fragmentation in monitoring data often caused by a lack of funding

(Bliss et al., 2001; Sharpe & Conrad, 2006). While there is general skepticism, there are studies conducted on the accuracy of volunteer-collected data. Many have indicated that volunteer-collected data can be comparable to that of expert-collected data (Fore, 2001; Engel & Voshell, 2002; Nicholson, Ryan & Hodgkin, 2002; Foster-Smith & Evans, 2003, Monk et al., 2008); these studies encompass biological, physical, and chemical water monitoring parameters.

Despite the abundance of CBWM organizations, there remains a gap in academic literature regarding the benefit, *if any*, that the existence of CBWM provides to the natural ecosystem (Conrad & Hilchey, 2011). Although there exists subjective evidence regarding the environmental benefits of CBWM and citizen science within grey literature, more peer-reviewed literature must be established to validate these claims (Conrad & Hilchey, 2011). To address this gap, Conrad and Hilchey (2011) identify a need to compare and contrast cases where citizen science and CBWM have influenced benefits to the ecosystems being monitored. Therefore, this paper will: (1) identify cases where there are potential observable or measurable benefits to ecosystems that are being monitored through CBWM; (2) contrast these cases with existing literature to see to what extent, *if any*, the activities of CBWM organizations are impacting the ecosystem; and (3) discuss areas of strengths and weaknesses and factors that could aid in improvements.

### **3.5 Water Monitoring and Restoration**

The quality of a water source is determined by evaluating its physical, chemical, and biological traits (Khalil et al., 2010). Each evaluation method has its strengths and weaknesses, and plays a role in identifying the current state of aquatic environments. These traits can also be used to track the success of restoration efforts within the system, although implementing the monitoring procedures to do so can be challenging. While there has been an ever-increasing interest in conducting restoration projects, there has not been a major advance in the knowledge of how to successfully implement restoration (Osborne et al., 1993; Hobbs & Norton, 1996; Ehrenfeld, 2000; Lake, 2001; Palmer et al., 2005). Despite the abundance of restoration projects and the immense amount of time,

money, and resources invested into them, few projects incorporate the monitoring necessary to determine if the project was successful or not (Palmer et al., 2005; Feld et al., 2011, Pander & Geist, 2013). Very little documentation or data have been developed to highlight the steps required to implement restoration in freshwater aquatic ecosystems successfully (Bond & Lake, 2003; Alexander & Allan, 2007; Feld et al., 2011), and even among the projects that are evaluated, many of them lack the procedural implementations that allow for thorough scientific analysis (Chapman & Underwood, 2000; Bond & Lake, 2003). There are multiple factors that contribute to this, but some of the major ones are: lack of understanding, agreement, funding, and scale of restoration being conducted. Some grey literature documents have been developed within Canada to aid in restoration and best management practices (see Keenleyside et al., 2012; Parks Canada, 2013), but these sources are for restoration in general and not specific to aquatic ecosystems.

Aquatic ecosystems are complex, containing numerous physical, chemical, and biological relationships that influence biodiversity, water quality, and habitat that are not fully understood (Kondolf, 1995; Graf, 2001; Pess et al., 2003; Wohl et al., 2005). These relationships are further complicated by each system being unique; therefore successful restoration in one aquatic ecosystem does not necessarily mean that the technique used would be transferable to another (Hilderbrand, Watts, & Randle, 2005). Within the scientific community there is a general consensus that restoration is important, but there are multiple views on what successful restoration constitutes, the process required to achieve this goal, or the monitoring procedures required to properly track and document ecosystem changes at a project level (Roni et al., 2002; Palmer et al., 2005). When planning and conducting restoration, the current funding structure favors action-oriented projects, meaning that funds are often allocated to conduct the physical project work but cannot be used to support pre- and post-project monitoring (Kondolf, 1995; Wohl et al., 2005). Lastly, large-scale restoration has been identified as having a higher chance of success, as changes in the aquatic ecosystem will be more significant and easier to monitor and track (Shields et al., 2003; Lake, Bond, & Reich, 2007). Unfortunately, large-scale projects are not often economically or socially feasible due to limited resources and conflicts of interest (Shields et al., 2003; Lake et al., 2007); in these



instances small-scale restoration can be effective at targeting specific problems, but changes at this scale can be difficult to monitor and track (Lake et al., 2007).

Both citizen and professional scientists agree that monitoring of restoration projects is a key component in determining project success (Jungwirth et al., 1995; Kondolf & Micheli 1995; Schiemer et al., 1999; Nienhuis et al., 2002), but there are also other key factors to consider. Kondolf (1995) highlights 5 elements for effective stream restoration: (1) clear objectives; (2) baseline data; (3) good study design; (4) commitment to the long term; and (5) willingness to acknowledge failure. Lake (2001) highlights the need for restoration projects to have participation from resource management agencies, adequate design with a clear goal that utilizes pre-restoration data, proper monitoring (physical, chemical, and biological), transparent reporting of the project outcome, and consideration as to the time required for natural processes and biota to recover. Palmer et al. (2005) suggest that success should take into account 3 different aspects: stakeholder values, project learning outcomes, and ecological success. Palmer et al. (2005) further divides ecological success into 5 categories: (1) a clear guiding image of the aquatic system in a state that is achievable by restoration; (2) the targeted physical and chemical components of the system are measurable and enhanced; (3) restoration leaves the aquatic system in a state where it can become self sustaining without continual maintenance; (4) restoration projects leave no lasting harm within the system; and (5) information regarding the conditions of the project site is collected both before and after the project and made publically available .

Another important aspect of restoration is strategically targeting known impacts that affect aquatic ecosystem biodiversity, habitat, and water quality; the mitigation of these impacts will prevent further degradation to the ecosystem and allow for natural restoration to take place (Kauffman et al., 1997; Jähnig et al., 2010; Ruwanza et al., 2013). Beechie et al. (2008) proposes a hierarchical approach to restoration based on the probability of success, response time within the aquatic ecosystem, and longevity of the restoration method implemented. First, this approach should focus on the protection of high-quality habitats, as this provides the greatest benefit to the aquatic ecosystem

(Kauffman et al., 1997; Roni et al., 2002; Beechie et al., 2008); second, restoration actions should target the reconnection of fragmented habitat (Beechie et al., 2008; Roni et al., 2008); and third, processes that maintain and create habitat should be restored (e.g. flow regime, water quality, riparian habitat) (Beechie et al., 2000; Bohn & Kershner, 2002; Roni et al., 2002; Beechie et al., 2008).

Within the literature there are some prominent criteria for restoration success: clear project goals and objectives (Dahm et al., 1995; Kondolf, 1995; Lake, 2001; Palmer et al., 2005; Jähnig et al., 2010); the collection of baseline data and pre-restoration conditions (Kondolf, 1995; Chapman, 1998; Lake, 2001; Palmer et al., 2005; Bernhardt & Palmer, 2011); and clear reporting or documentation of the outcome (Lake, 2001; Nienhuis et al., 2002; Palmer et al., 2005; Pander & Geist, 2013). Restoration activities should be strategically targeted to prioritize the preservation of high-quality habitat, reconnection of habitat, and restoring processes that maintain and create habitat (Kauffman et al., 1997; Roni et al., 2002, 2008; Beechie et al., 2008).

### **3.6 Case Context**

My research involved working with 5 CBWM organizations within Atlantic Canada to assess the processes utilized to plan, implement, and complete restoration projects. At the time of data collection all 5 organizations were partners in the CURA H2O Research Alliance, a 5-year Social Sciences and Humanities Research Council of Canada (SSHRC) funded project for community-based integrated water monitoring and management in Atlantic Canada and abroad. The CURA H2O Research Alliance provided a collaborative network where citizen groups and academics worked together to develop standardized data collection methods, and provided academic guidance to CBWM organizations and vice versa.

## 3.7 Methods

### 3.7.1 Recruitment, Data Collection, and Data Analysis

Of the 20+ CBWM organizations affiliated with the CURA H2O Research Alliance, 5 were recruited to participate in my study, based on the capacity of the project and existing sample pool. These organizations were selected using a purposeful sampling method (see Patton, 2002), seeking the participation of key informants from each organization. A key informant is defined as persons who have in-depth knowledge about past and present activities of their CBWM organization, and are actively involved in planning and organization (McKenna, Iwasaki & Main, 2011).

Five inclusion criteria for CBWM organizations to participate in my study were: (1) currently participating in the CURA H2O Research Alliance; (2) a CBWM organization that had been established for a minimum of six years (to ensure the potential for observable outcomes of any monitoring activities (Leach, Pelkey, & Sabatier, 2002); (3) retention of members who were knowledgeable of historical and current activities of the CBWM organization; (4) maintenance of supplementary records of activities conducted (e.g., photographs, project reports, and journal logs); and (5) having conducted continuous monitoring throughout this timeframe and retention of data records.

Selection of key informants was based on 5 inclusion criteria: (1) they were self-identified, group-identified, or identified by the CURA H2O research team; (2) they were voluntary and willing participants (Whiting 2008); (3) they were involved in the planning, organization, and implementation of CBWM activities (Whiting 2008; McKenna et al., 2011; Stewart & Cash 2011); (4) they had in-depth knowledge of the past and present activities conducted by their CBWM organization, and could explain the process from start (planning) to finish (follow-up); (5) and they were a primary source of information, someone who was directly involved with the information being provided (Stewart & Cash, 2011). A total of 8 participants were recruited from the 5 CBWM organizations (see Table 3.1).

Table 3.1: Key Informant Guide.

Participant Code	Organization	Province	Organization Established (years)
P-01 P-02	CBWM#1	Nova Scotia	~ 27
P-03	CBWM#2	New Brunswick	~ 21
P-04 P-05	CBWM#3	Nova Scotia	~ 11
P-06 P-07	CBWM#4	Prince Edward Island	~ 21
P-08	CBWM#5	Nova Scotia	~ 25

### 3.7.2 Data Collection and Analysis

A two-tiered interview structure was used for data collection consisting of Phase 1 – semi-structured interviews, and Phase 2 – photo elicitation. Phase 1 interviews were used to gain general knowledge about the CBWM organizations and to verify key informant participation. The end goal of the Phase 1 interview was to identify subject matter suitable to use in the second phase of the research study: activities conducted by the CBWM organization that have the ability to benefit the natural ecosystem and have photographic documentation. A code list was used to identify *a priori* codes generated in consultation with the CURA H2O research group and during the literature review (Gibson, 2009; Willig, 2013). These codes were imputed into the data in a deductive analysis during the first reading of the interview transcript (Crabtree & Miller, 1999). A second round of coding was conducted using inductive analysis to identify and categorize newly emergent themes that were not identified in the deductive analysis (Tracy, 2013). A code list was updated and maintained throughout this process that defined and kept track of all of the codes used in the analysis (Tracy, 2013). After coding was completed, top-level codes were identified and classified as parent codes (Gibson, 2009). All other codes were classified as child codes and organized under their corresponding parent code.

Phase 2 interviews focused in-depth on 3 to 5 activities that were identified by participants during the Phase 1 interview. Participants were requested to supply photographs that depicted the activity areas pre, during, and post activity. These were printed and displayed during the interview. Photo elicitation interviews, in which photographs are used to facilitate the conversation (see Harper, 2002), were employed to discuss the planning for, implementation of, and follow-up to each activity. When available, accompanying monitoring data and project reporting was requested for the activities discussed. Analysis of Phase 2 interviews followed the same coding structure as described for Phase 1 interview analysis. New parent and child codes were identified during this analysis and were defined, classified, and incorporated into the analysis.

Phase 1 and 2 interviews were transcribed verbatim and coded using NVivo10™, a qualitative data analysis software program. All data were scrutinized using thematic analysis (Aronson, 1994) to identify process, methods, and practitioners involved in each project type.

In total 8 individuals from 5 different CBWM organizations participated in this study. One organization did not participate in Phase 2, as the participant indicated that they did not have any activities that fit the research criteria. A total of 23 projects were discussed during the Phase 2 interviews, with 15 projects matching the research criteria of having the ability to impact or enhance the aquatic environment. These projects were the focus of the analysis. The remaining 8 projects were outliers; projects such as public education, staff training, school programs, projects still in the planning stage, and baseline monitoring programs. Although these projects are relevant, their impact on the ecosystem has no unit of measure or visual indicators to determine how they affect the aquatic ecosystem.

### 3.8 Findings

Through the interviews conducted with the CBWM organizations major themes that shape restoration projects were identified: (1) a majority of the restoration projects require regulatory approval; (2) projects were planned and implemented with clear goals and objectives; (3) funding sources and land availability often restrict the size and scope of projects, and the extent to which monitoring is conducted; (4) monitoring at a watershed scale is inadequate to detect environmental changes at a project specific level; (5) post-project reporting was completed for all projects that required regulatory approval, and reports were made publically available for 7 of projects; and (6) a majority of restoration projects were targeted at reconnecting habitat and restoring processes that create and maintain habitat.

The following sections are structured to, first, discuss the general aspects of the restoration process, and second, focus more specifically on the individual project categories identified in Table 3.2. The findings include 3 project cases that are used to demonstrate specific restoration projects in depth: Case 1 – Dam Removal; Case 2 – Sediment Control; and Case 3 – Riparian zone restoration.

Table 3.2: Summary of Restoration Projects.

Project Type	Number of Projects Assessed	Anthropogenic*	Naturally Occurring**	Regulatory approval required (# of projects)
Habitat connectivity and fragmentation	6	5	1	6
Sediment control and riparian zone enhancement	4	4	0	4
In stream enhancement	2	2	0	1
Out of stream enhancement	3	3	0	0

\*Projects that were triggered due to anthropogenic influences.

\*\*Project that were triggered due to naturally occurring influences.

### 3.8.1 Project Approval Process

Each of the CBWM organizations operated under a ‘blanket permit’ or ‘blanket approval’ issued by Canada’s federal Department of Fisheries and Oceans or one of the provincial regulatory agencies (Nova Scotia Environment, Prince Edward Island Department of Environment, and New Brunswick Environment), allowing them to conduct small-scale watercourse alterations. These permits grant permission for CBWM organizations to conduct in-stream and terrestrial work within a defined geographic location. Work conducted under the permit had to be approved by regulatory agencies before it could be conducted. Projects that were considered low risk impact aquatic environments, such as garbage removal or tree planting outside of the riparian zone, were exempted from approval under the permit.

*“What we have to do is submit notification just in case they [the regulatory agency] have any concerns a couple weeks in advance of doing the work. So we submit the geographic location, the description of the work that we’re going to do, [and] the dates that we intend to do the work...” (P-08)*

If the regulatory agency has any questions or concerns regarding the project, they must be addressed before projects are approved. Additionally, regulatory agencies may request the preparation of a detailed project plan that highlights the goal of the project, the procedural implementation, and documentation that supports the methodology of the technique being used. Permits stipulate the timeframe in which projects can be conducted and for any work that falls outside this timeframe the permit must be amended.

*“So we have a permit... you can’t get into the streams until the first of June and that takes us all the way until the first of December that we can do in-stream work.” (P-07)*

*“After that we would have to get, basically, an amendment to our blanket permit if we were to extend it to going in after December. Additionally, if we have a*

*major obstruction, like a beaver dam, we would have to get additional permission from the province to go and remove that depending on the scale.” (P-06)*

Moreover, landowner approval is required to conduct projects on privately owned land; however, landowner approval does not absolve CBWM organizations from obtaining regulatory approval.

### 3.8.2 Project Planning, Conducting, and Follow-up

Project planning was primarily conducted within CBWM organizations with professional, academic, and regulatory consultation when required. Project planning was influenced by funding sources, group capacity, procedural documentation, access and availability to project locations, monitoring data, and expertise. Outside expertise was often utilized when implementing new restoration strategies or when organizations lacked the capacity or equipment to conduct a project. Organizations also sought training for restoration techniques where they lacked experience and expertise. Ten of the 15 projects utilized expert consultation in the project planning process.

*“Well the planning of this was to develop a training session with the Guardians so they have some awareness, knowledge, of digger logs; what they are used for, how they’re implemented, how to put them in. So this is an exercise to get them [the guardians] awareness of that, to actually apply it in real situations.” (P-05)*

In 12 of 15 projects, the project location was identified during watershed surveys where specific areas were targeted and assessed visually by CBWM staff. Visual assessment was an important tool in identifying project locations, and as a trigger for more in-depth assessment to be conducted. Specifically, visual assessment was a key component in identifying and assessing sedimentation sites, riparian zone conditions, and barriers to connectivity. In 3 of 15 projects, water-monitoring data were used to identify areas of concern within the watershed. Changes in monitoring parameters between established upstream and downstream monitoring locations were detected in these cases.



All 15 projects identified clear goals and objectives, although on a majority of projects such small-scale change was difficult to verify through water quality monitoring or biotic indicators. This was commonly addressed by CBWM organizations when discussing the impact of small-scale projects at a watershed scale. On a majority of projects CBWM organizations stated that the project outcome was observable through visual monitoring, but that water-monitoring results were inconclusive. Although each of the CBWM organizations was actively conducting continual water quality monitoring within their watersheds, monitoring at this scale did not detect change that could be directly related to restoration. Project specific monitoring was conducted on 4 of 15 projects, in these cases physical, chemical, or biological change was detected.

In 12 of the 15 projects, the project was dependent on outside funding and in-kind contributions. Funding sources often restricted the scope of the project, determined the project type, influenced the size of project, and the extent that monitoring could be conducted.

*“A lot of the funding we get for this type of project specifies that it’s for action; it’s for environmental action, environmental improvement, but there is nothing provided to measure that improvement. So we very seldom have that opportunity, the funds, the capacity, to do before and after [monitoring] to actually evaluate the impacts of our projects.” (P-08)*

On projects where funding was for action only, any monitoring conducted came at a cost to the CBWM organization. With limited budgets, CBWM organizations indicated that these projects often lack the monitoring data necessary to track environmental changes.

During project implementation CBWM organizations took a lead role in project coordination and supervision in all 15 projects. This role was shared on 5 of the 15 projects where contractors were hired to aid in planning and conducting the project. Personnel from regulatory agencies visited project worksites on 6 of the 15 projects to

assess project work and ensure compliance. CBWM organizations indicated that regulatory agencies did not have the capacity or personnel to visit all project locations. On a majority of projects, regulatory agencies relied on project reporting to inform them about the project; CBWM organizations stated that for this reason photographic documentation of projects was important in order to give visual reference to project activities.

*“They [the regulatory agencies] probably never come out to the site, I think they relied on the pictures that I sent them. But one of them, one individual from those two groups, may have come out to the site to look at it, but I think for the most part, given the site and given our experience, they trust us to do it.” (P-02).*

*“The science, what we’re observing and marking in our notes, you can physically see the changes that are happening in the streams, and we think that site photos are an integral part of any project so that you can track your success or failure, essentially.” (P-06)*

Upon completion, all 15 projects had periodic site visits conducted where CBWM staff visually assessed site conditions and took photographs. In 4 projects, project specific water monitoring data were collected. Post project reporting was conducted on 13 projects, with reports made publically available for 7 of these projects.

The following sections provide a synopsis of each of the 15 projects, organized by the 4 project types (i.e., Habitat Connectivity & Fragmentation; Sediment Control and Riparian Zone Restoration; In Stream Enhancement; and Out of Stream Enhancement). These contain 3 case studies (i.e., Case 1 – Dam Removal; Case 2 – Sediment Control; Case 3 – Riparian Zone Restoration) that detail specific projects. These sections identify the factors that influenced and shaped each of the projects, and how restoration influenced environmental change.

### 3.8.3 Habitat Connectivity & Fragmentation

The highest concentration of projects, 6, focused on habitat connectivity and fragmentation. These projects implemented the objective of removing or enhancing identified barriers within stream networks to allow for fish passage and thus alleviate habitat fragmentation. All barriers were identified through visual monitoring and assessment, and 3 were verified through standardized monitoring protocols. Five of the 6 barriers were anthropogenic in nature, 4 culverts and 1 dam (see Case 1- Dam Removal), and 1 was naturally occurring.

For 2 of the culvert restoration projects a protocol for assessing culverts was adopted from Nova Scotia provincial guidelines (to determine non-barrier culverts), from British Columbia Ministry of Environment (Parker, 2000), Terra Nova National Park (Coté, 2009), the U.S. Department of Agriculture, Forest Service, National Technology and Development Program (Clarkin et al., 2005), and the Department of Fisheries and Oceans Canada (DFO, 2007). Sub-watersheds within the larger watershed were strategically targeted based on water chemistry and potential salmonid habitat. Culverts within the targeted areas were assessed based on water quality, culvert type (i.e. shape, material, entry type), embeddedness, length, and slope. Restoration was conducted on culverts assessed as barriers to fish passage, consisting of debris removal, flow regulation, and ensuring that fish could enter and exit the structure. Culverts were then reassessed to ensure that fish passage had been restored. This methodology is being standardized within the province of Nova Scotia, for assessing culverts that cannot be removed from streams.

On the remaining 2 culvert projects, visual assessment, and in 1 case a concern for human safety, triggered the projects. In these cases the projects involved the removal of culverts from the outflow of a lake, and from within a feeder brook that connected to the main stream channel (see Figure 3.1). The structures had originally been installed by a logging company to provide road access across the river, and by a developer for road access to a

development that no longer exists. Both roadways had been abandoned and deteriorated to a state where stream crossing was no longer possible, however they still represented a barrier to fish.

*“In this case, we knew that there was pretty much a complete blockage to fish passage. And of course that depends on flows as well, but there was a blockage of fish passage. And that was the only issue, and that was so apparent that there wasn’t really much need to do flow data or anything like that, so there really wasn’t much in the way of monitoring in advance to the project.” (P-02)*

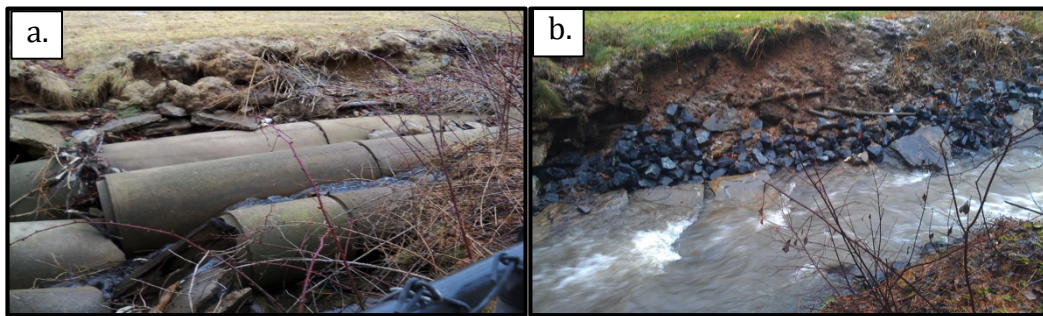


Figure 3.1: Cement culverts in a feeder brook that were visually assessed as a complete blockage to fish passage a) pre-removal, and b) post-removal.

Before the removal of the structures, the project locations were visited with federal and provincial officials who verified the work plan, and approved the project. Project work was conducted within a day for each project, where culverts were removed, banks stabilized, and waste disposed of. Pictures were taken throughout this time, as regulatory agencies were unable to come to the project locations as work was being conducted. Each site was periodically assessed after project completion to ensure that site conditions were being reestablished. Although monitoring data were not collected for these projects, the CBWM organization indicated that the resulting benefit to the ecosystem was readily observable, as natural flow regime and connectivity was restored.

The mitigation of a naturally occurring barrier, a waterfall, utilized the construction of a fishway. The waterfall was a known barrier to fish passage at low water conditions, and

poaching at this location was frequent. The project was first proposed, planned, and designed by the Department of Fisheries and Oceans. The agency then approached the local CBWM organization with their plan and asked if the organization could provide a portion of the funding for the project, oversee construction, maintain the structure, and conduct annual fish surveys. The CBWM organization was successful in obtaining grant funding from the provincial government and hired a workforce to build the structure. The fishway was successful in allowing fish passage through the waterfall during low water conditions and poaching has decreased significantly. The fishway acts as a salmon monitoring station, and has been utilized for multiple university research studies.

*“Also, there’s unexpected side benefits. There have been several surveys carried out at the fishway on gaspereau, on eels. People actually see that [the fishway] as a place to do scientific work.... We have now become a focal point in some cases for some types of research. And because we go there every day, counting the salmon and other species, it’s also good for us to do water quality monitoring.”*

(P-01)

The CBWM organization reports to the federal agency monthly on the numbers of fish passing through the structure during operation.

### **Case 1 – Dam Removal**

Originally built to create a drinking water reservoir, the dam passed through multiple ownerships before being abandoned (see Figure 3.2). Existing on a salmon spawning river, concern for the dam’s structural integrity and salmon poaching taking place at the obstruction was brought to the attention of the CBWM organization by a concerned citizen. Consultants were hired to conduct a feasibility study on removing the structure that included hydrological impacts of dam removal, archaeological assessments, legal reviews, and risk assessment for downstream landowners. Public consultation was conducted within local communities and fish surveys confirmed the existence of salmon, American eel, and brook trout within the stream. The decision taken from the feasibility

study, public consultation, and fish surveys was that the dam should be removed. Funding for the project was obtained by the CBWM organization. Project planning was finalized through collaboration between the CBWM organization and consultants as well as provincial and federal agencies.

Pre-project monitoring began in 2009 where dissolved oxygen, pH, temperature, conductivity, elevation surveys, benthic macroinvertebrates, grain size analysis, fish passage, and photo monitoring procedures were put in place. It was concluded that the dam was a blockage to fish passage and a safety hazard due to the risk of structural failure. The structure was removed in September 2011, restoring migratory passage to an estimated 19.1 km section of riverine habitat. Post-project monitoring began immediately after the dam was removed and continued until fall 2012, photo documentation of the project continued until summer 2013.

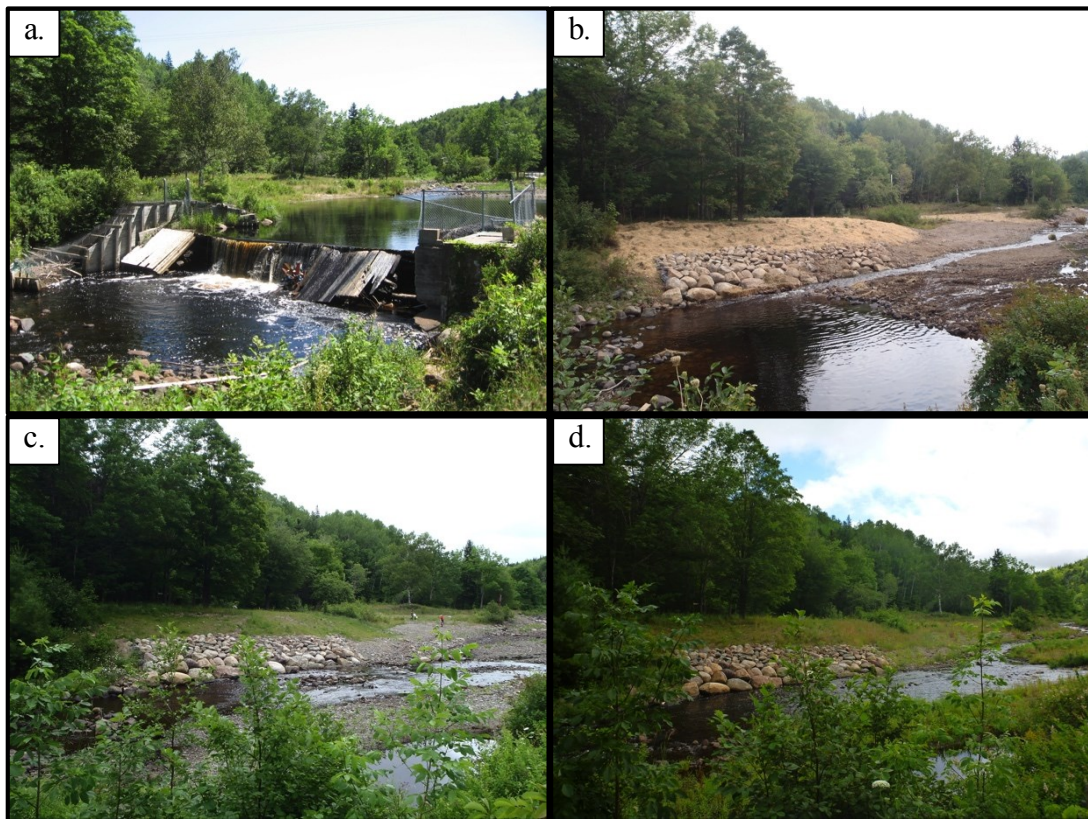


Figure 3.2: Dam removal project photo documentation. a) pre-removal Aug 6, 2009; b) post-removal Sept 14, 2011; c) post-removal July 6, 2012; d) post-removal July 29, 2013.

Post-project monitoring for temperature, conductivity, dissolved oxygen, and pH did not show any significant changes from pre- to post-removal monitoring conditions; however, there was a slight increase in dissolved oxygen concentrations, and a decrease in water temperature. Although this could be indicative of a beneficial ecosystem shift due to removal of the dam, it is speculated that this was caused by variations in climate from year-to-year. Benthic macroinvertebrate monitoring showed a significant increase in the percent of ephemeroptera, plecoptera, and trichoptera (%EPT) communities within the former reservoir of the dam indicative of a positive ecosystem shift, whereas the upstream control site showed a slight decrease in %EPT. Upstream and downstream monitoring locations from the dam removal site showed little change in %EPT over the course of monitoring. The most notable change between the 2011 to 2012 post-removal timeframe was the percentage of bare soil from 39.8% to 0.4% within the restoration area, showing a positive shift in riparian zone reestablishment. Photo documentation shows the reestablishment of plant life and the river's riparian zone during this timeframe. No adverse environmental effects were detected due to the removal of the dam. Fish surveys continue to be conducted within the river to track the response of fish species to the removal of the dam. At the time of the interview fish surveys were inconclusive and required a longer monitoring period to determine the state of fish stocks.

On all 6 projects, participants stated that the desired project outcome was achieved and connectivity was restored to the system. In 3 of 6 projects, project success was based on observation and monitoring data of pre and post project conditions. In the remaining projects success was based on observation and visual assessment of pre and post project conditions.

#### 3.8.4 Sediment Control and Riparian Zone Restoration

The second highest concentration of projects, 4, addressed sedimentation control and riparian zone restoration. The goal of these projects was to reduce in-stream sedimentation and to reestablish riparian zones. Monitoring data were used to identify sections of the river where restoration activities would be targeted for 3 of the projects.

Sedimentation sites were also confirmed visually by tracking sediment plumes during rain events, and by assessing stream bank and riparian zone conditions.

*“We were monitoring the streams after rain events. We did three samplings on every site; it had to be before a major rain event, during a major rain event, and after a major rain event.” (P-06)*

*“What we were looking at is we were actually tracking the movement of the silt to find out.... So what we were trying to do is actually track it back to see where the source was, to find it.” (P-07)*

In all cases project funding came from government sources, 3 federal and 1 provincial. Funding was for restoration action only, and project specific water monitoring was not conducted. Although water monitoring was conducted throughout the course of the projects at locations upstream and downstream from the project locations, the data was inconclusive to changes in water quality indicators. CBWM organizations indicated that changes in water quality are difficult to detect and correlate at the scale that monitoring and restoration was being conducted. They reported that benefits to the ecosystem were observable but not measurable in these cases.

## **Case 2 – Sediment Control**

Constructed in the early 1960s and operated until the 1980s, a rock quarry was established on a river to mine river rock. The watercourse was altered in order to access the streambed, and when operations ceased, the pit was abandoned. The river remained diverted in such a way that it undermined a large slope adjacent to the river causing significant erosion and sedimentation. The site was approximately 110 m long and 30 m high (see Figure 3.3). In the early 1990s, the CBWM organization and the provincial government conducted a site assessment and concluded that the site should be restored to prevent environmental harm to the river. The environmental concerns identified were sedimentation and the possibility of the river diverting its course for approximately 1 km



through forested land by washing through the bank of the new channel. Restoration work was conducted on the site numerous times by hand, but the site continually washed out under high water conditions. The CBWM organization lacked the capacity and funding to conduct work at a larger scale, but in 1995, the project received federal funding. The CBWM organization hired an engineering firm to develop a restoration plan for this section of the river. The restoration plan received federal approval and provincial permitting was secured. During low-water conditions large rocks were brought into the site and placed against the stream bank with heavy equipment. Gradient controls were constructed within the stream channel so the river could reestablish its natural grade and to create holding pools for migrating fish. The riparian slope was then seeded with grass and trees were planted to stabilize the soil.

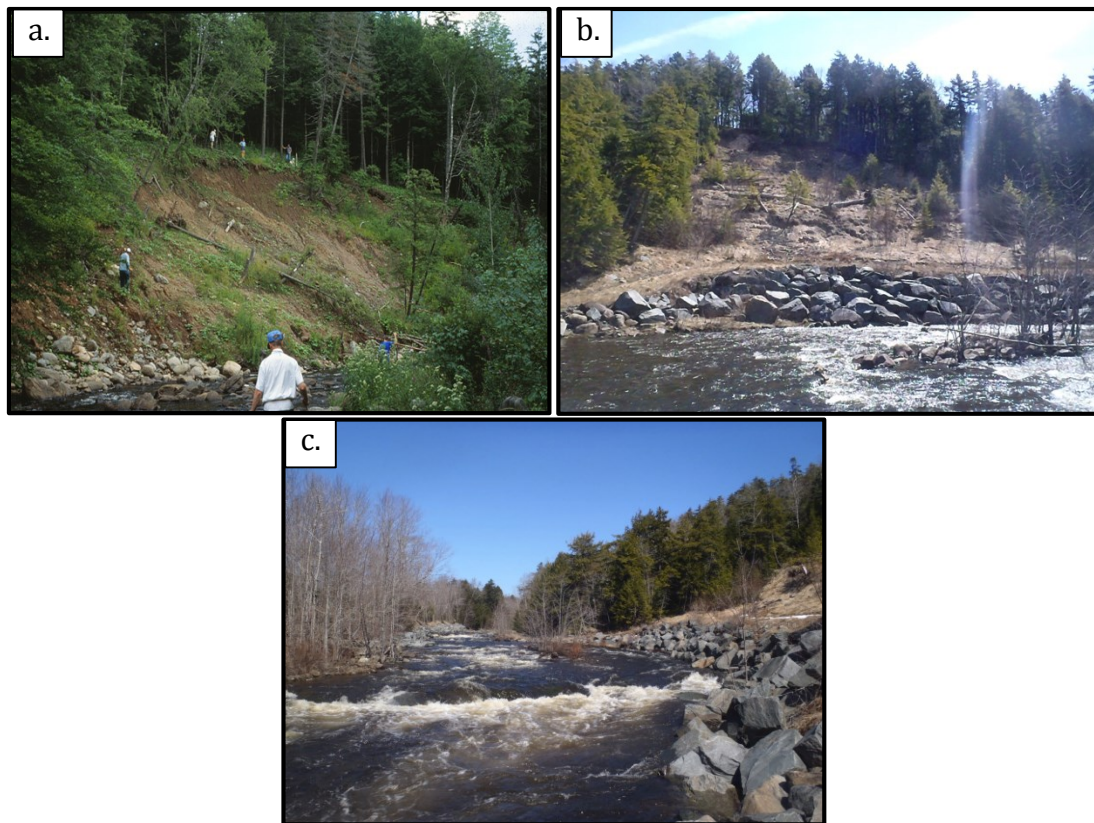


Figure 3.3: Sediment site rehabilitation. a) pre-restoration site condition; b) post-restoration site condition; and c) post-restoration looking upstream at river channel gradient control structure.

Throughout the project the site was visually monitored and photographs were taken to document site conditions. The site is visited periodically to assess conditions and determine whether any maintenance work is required.

*“In my opinion we didn’t do any proper measurements but [there is a] huge reduction in the amount of silt leaving the site; huge amount, major reduction. And we may have saved the river from re-channelizing itself for about a kilometer or more, which would have meant huge amounts of environmental damage.”*

(P-01)

Figure 3.3c shows that slope erosion has been mitigated at the site, indicating that sedimentation from the site has been prevented. The slope shows vegetative cover and the footing of the slope no longer descends directly into the river. However, without water monitoring data, it is not possible to determine the amount of sediment that has been prevented or reduced, or any responses in the aquatic environment due to this action.

### **Case 3 – Riparian Zone Restoration**

As part of a strategy to rehabilitate riparian zones, prevent sedimentation, and control animal access to waterways, one CBWM organization has targeted agricultural landowners seeking permission to implement ‘riparian best management practices’ on their land. Riparian zone management is of concern throughout this particular watershed as over 50% of the riparian habitat along the main waterway is on agricultural cropland. The CBWM organization identified this specific segment of the river through water quality monitoring, which detected a spike in *E. coli* between 2 established monitoring locations. Riparian zones within this area were visually assessed to identify areas of concern and potential project locations. The CBWM organization then contacted landowners within the area seeking permission to conduct work on their land. Once approved, a site-specific assessment was conducted and restoration options were identified and discussed with landowners. In this case, a landowner was contacted to discuss an erosion site situated on his/her property. As part of the process, the landowner

voluntarily allowed a portion of their land to be established as a riparian buffer where no farm activities would occur. The CBWM organization and landowner agreed on ‘live staking’ erosion control as a restoration option, a process whereby live cuttings (stakes) from plants are planted in the ground to root and hold soil in place (Fay, Akin, & Shi, 2012). Permits for conducting the project were obtained from provincial and federal regulating agencies. Stakes were collected from a nearby willow stand and planted by hand on the eroding bank.

*“...it went from a big exposed sand bank to a well vegetated bank and now the willow sills that we planted are almost unrecognizable, they’re just massive clumps of willow shrub and they’re really helping the slope stabilize and other vegetation to establish itself on the soils.” (P-08)*

Upon completion, the project site was surveyed periodically to monitor the reestablishment of vegetation. Photos of the site and surveys show that vegetation was reestablished and that bank erosion has been controlled (see Figure 3.4). The impact of this project is observable, although project specific water monitoring was not conducted.

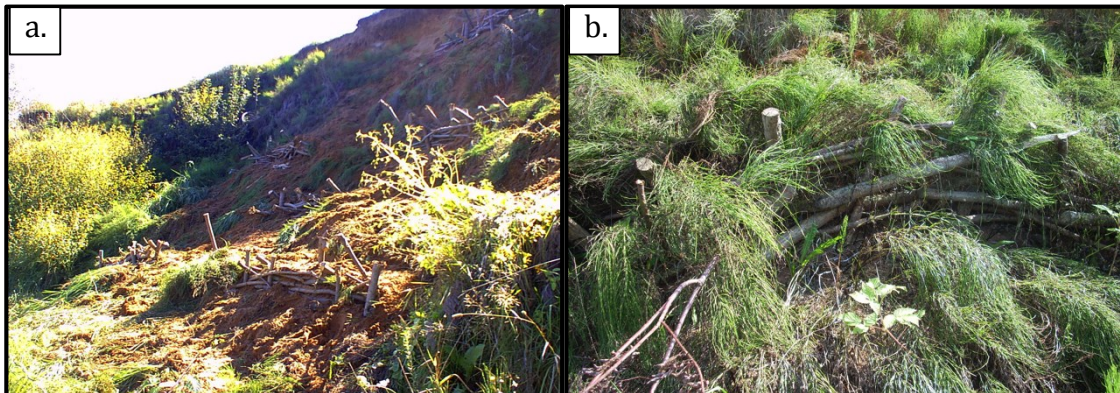




Figure 3.4: Restoration of an erosion site using live staking. a) sill boxes installed on an eroding bank for the live staking process; b) vegetative regrowth on the slope 5 years after restoration; and c) willow growth from live staking process 5 years after restoration.

*“Observationally, the willow staking definitely retained a lot of soil on the location and allowed establishment of a lot more vegetation at the site; so I mean it’s observable, I guess; it’s not anything measurable.” (P-08)*

The lack of water monitoring on this project is attributed to the project funding structure with funding received through the Environment Canada – EcoAction Community Funding Program. Although applicants are required to report on how their project will lead to positive, measurable environmental results, the provided list of environmental indicators for water are not capable of measuring positive responses in water quality or aquatic communities: amount of diverted toxic waste, reduction of water consumption, area of shoreline restored, and percentage of recommendations from environmental management plans implemented (Environment Canada, 2013). The CBWM organization expressed the need for more complete funding sources to help develop future projects.

*“It would be nice to have funding in future years, have like three-year continuous funding where we could do more evaluation of the work we are doing. That would help develop projects in the future, but most of it is observational, unfortunately, with this.” (P-08)*

### 3.8.5 In-Stream Enhancement

Two of the 15 projects focused on in stream enhancement. These projects were digger log installation and in-stream garbage removal. Digger logs were utilized on sections of small streams that were historically channelized in order to reestablish natural flow regimes and create habitat. Site assessment of digger log locations was conducted by the CBWM organization in partnership with a provincial ‘Adopt a Stream’ program. Sections of river were visually assessed and measured to determine the locations where structures would be installed. Water quality monitoring and measurements of the river’s physical characteristics were collected both before and after the installation of a digger log. Fish population surveys were conducted when conditions allowed for electrofishing.

Post project monitoring indicated that dissolved oxygen content within the water increased directly after installing the digger log, that pool habitat was formed, and that the stream channel was deepened and narrowed. Participants indicated that data on fish populations were inconclusive due to restrictive timeframes on when electrofishing can be conducted and varying results in fish abundance pre and post project. Each digger log structure required maintenance on an annual basis, whereby the CBWM organization would remove debris caught by the log, remove rock and sediment from the pool habitat, place rock on the deflector, and replace logs that had been damaged.

Garbage cleanup from streams does not require project approval as it is considered non-intrusive and has a low probability of negatively affecting streams. This particular CBWM organization has been conducting organized garbage removals for approximately 20 years, relying on the participation of community volunteers. Over this time, the CBWM organization has indicated that the volume of garbage being removed from the river has decreased and that the composition of the garbage has changed.

*“Going from 1988 to 2014, we’re finding that slowly the garbage content is changing. We’re getting less and less car parts, less and less fences, less and less*

*what I call original garbage; people who built a house and threw it [the garbage] in the river. Times are changing.” (P-01)*

In the first year of conducting the cleanups approximately 50 cars were removed from the river system. Over the years, numerous oil drums, tires, shopping carts, scrap metals, plastics, and rubber waste have been removed from the river system. The garbage that is currently being removed from the river consists primarily of plastics such as grocery bags and bottles. It is uncommon to find newly disposed of construction debris, metals, tires, or oil drums. The result of the garbage removal from the river has been observable, but the CBWM organization stated that they would not know how to monitor the consequent impacts to the river system.

### 3.8.6 Out of Stream Enhancement

A total of 3 projects focused on ‘out of stream’ habitat enhancement’. These included habitat enhancement for monarch butterflies, hedgerow planting in farm fields, and an educational program on river assessment conducted in local schools. These projects relied on community engagement and public support.

Hedgerow planting and monarch habitat enhancement required landowners to voluntarily dedicate sections of land that would no longer be used for agriculture or other uses. The benefit to landowners was that hedgerows would aid in the prevention of topsoil erosion. Monarch habitat utilized the protection of wetland habitat that can aid in protecting streams by establishing riparian buffer zones, and marshes that can capture and help filter nutrient and fertilizer runoff. These wetland areas are normally of low economic value to farmers.

The educational program was administered in schools as a curriculum-matched river assessment program for grades 1-10. Working with teachers, each classroom that participates is assigned a section of a river where the students are responsible for scientific assessment. Facilitated by CBWM staff, students are guided through the

process of collecting and analyzing water monitoring parameters and conducting site assessments. The program incorporates both lab and classroom components. At the end of each program students collaboratively decide on an activity to conduct to enhance the stream.

*“The whole point of the program was not to have kids collect data for data sake. The kids actually go out, they analyze the stream together and as a group they come up with what they think is the health ratio of the stream and then they come up with an idea of what is affecting it and how to enhance it.” (P-07)*

These projects demonstrate how CBWM organizations are collaborating with the community to protect their watersheds.

### **3.9 Discussion**

CBWM organizations are actively conducting restoration projects that are intended to mitigate or prevent anthropogenic harm to aquatic ecosystems. An abundance of data exist verifying that anthropogenic stressors such as sedimentation, habitat fragmentation, and riparian zone removal, have negative affects on water quality, aquatic habitat, biodiversity, and natural stream processes. Excessive sedimentation poses a major threat to aquatic ecosystems (CCME, 2002; USEPA, 2002; Benoy et al., 2012) and *“is one of the primary causes of stream corridor degradation”* (Shields, 2003, p. 442). When fragmentation restricts movement within aquatic ecosystems preventing species from accessing critical habitat, it has harmful effects on biodiversity that can lead to population decline or even extinction (Fausch et al., 2002; Fahrig, 2003; Letcher et al., 2007; Gardner, 2013; Branco, 2014). The removal of riparian zones leaves streams more susceptible to terrestrial influences, and can negatively impact in stream habitat and water quality (Osborne & Kovacic, 1993; Kauffman et al., 1997; Lake et al., 2007; Floyd, MacInnis, & Taylor, 2009). The literature on the response within aquatic ecosystems to the mitigation or removal of such anthropogenic stressors in many cases is unclear.

Through interviews that focused on restoration projects, major themes that correspond to criteria for successful restoration within academic literature were identified. Findings showed that: (1) projects are planned and implemented with the identification of clear project goals and objectives; (2) projects included baseline monitoring, but the collection of project specific water-monitoring data was rare; (3) post project reporting was completed for all projects that required regulatory approval, reports were made publically available for 7 of the projects; (4) a majority of restoration projects were targeted at reconnecting habitat and restoring processes that create or maintain habitat. Each of these findings is discussed in detail in the following sections.

### 3.9.1 Project Goals and Objectives

All of the restoration projects were planned and implemented with clear goals and objectives of the desired end result of each project. These were normally simple and straightforward involving the removal or mitigation of anthropogenic influences that are known to degrade aquatic ecosystems. A majority of projects involve governmental resource management agencies, and required regulatory approval. CBWM organizations were primarily responsible for the project planning process and determining the intended project outcome, but they also partnered with experts, academics, other CBWM organizations, and government agencies to aid with project planning to fill knowledge gaps within the organizations.

### 3.9.2 Collection of Baseline Data

The long-standing establishment of the CBWM organizations that participated in my study shows a commitment and invested interest to the long term within their watersheds. This establishment has allowed for the long-term collection of baseline data and documentation of pre-restoration conditions within their watersheds. Although CBWM organizations were monitoring at a watershed scale, it was expressed by participants that water monitoring at this scale was not sensitive enough to detect environmental changes directly correlated to the restoration work being conducted. The collection of project



specific water monitoring data was rare, and factors such as cost, capacity, and the project funding structure often inhibited the collection of such data. The literature states that larger-scale restoration projects provide the best opportunity to track changes within aquatic ecosystems (Shields et al., 2003; Lake, Bond, & Reich, 2007). This proved true for the restoration activities assessed during this study for biological indicators such as benthic macroinvertebrates, and most physical and chemical water monitoring parameters. Changes in physical characteristics were evident throughout all projects, showing that physical change can be documented at a small-scale.

Photographs were able to document the physical characteristics of pre-restoration site conditions. This form of baseline documentation was collected for all projects. When paired with physical measurements collected by CBWM organizations of pre-restoration conditions, this documentation allowed for a comparison of pre and post restoration where physical change was both observable and measurable. Changes such as the removal of barriers, establishment of riparian zones, and securing of erosion sites were evident within photographs. This can be used to track physical changes in restoration site conditions from before and after restoration is conducted.

### 3.9.3 Project Reporting

Project reporting is a critical step in the progression of restoration practices and techniques in that it can allow for knowledge mobilization around aspects of restoration that are and are not successful (Lake, 2001; Nienhuis et al., 2002; Palmer et al., 2005; Pander & Geist, 2013). Reporting can provide practitioners of restoration projects with valuable information on how to design and implement future projects. Two types of reporting were identified during this research: regulatory reporting and reports made available to the public.

Projects that received regulatory approval required the submission of a project completion report. This report is supplied to the regulatory agency but there is generally no requirement to make the report publically available. The reporting is utilized for

compliance and informing the regulatory agency but cannot be utilized by other practitioners. The regulatory reporting criteria vary depending on the type and scale of project; some forms of reporting are extensive others are minimal. For approximately half of the restoration projects examined during my research, reports were also made publically available by the CBWM organization, showing transparency in reporting on project outcomes as recommended in the literature (Lake, 2001; Nienhuis et al., 2002; Palmer et al., 2005; Pander & Geist, 2013). These reports were posted online on the CBWM organizations' websites.

#### 3.9.4 Prioritizing Restoration Activities

Based on the classification of restoration projects discussed, the majority focused on the reconnection of habitat within aquatic ecosystems. The remaining projects contributed both to the preservation of habitat, and restoring processes that maintain and create habitat. The prioritization of restoration activities was largely driven by the perceived benefit of project type along with factors such as cost, access to project location, project funding, and group capacity. Working with limited financial, staff, and land capacity, CBWM organizations showed a tendency to target restoration projects that are documented to yield the highest potential to benefit aquatic ecosystems, while requiring minimal cost and capacity. Funding streams often dictated the types of restoration that were conducted on an annual basis. The prioritization of project locations was influenced by access to the site. This limitation was most evident in watersheds with a high percentage of privately owned land, as landowner permission is required to gain access to project locations and conduct any terrestrially-based work. In these cases the prioritization of restoration was defaulted to where landowner permission was granted, meaning that projects were not always conducted at the optimal locations.

### **3.10 Concluding Comments**

Although many of the criteria discussed in the academic literature for successful restoration were satisfied, each were met to varying degrees. The most noticeable and

influential gap was related to the extent and type of monitoring being implemented on each of the projects. All of the projects discussed had clear and observable outcomes that were visible through photographic documentation, and further confirmed through visual monitoring and assessment. Only a portion of the projects had corresponding water monitoring data of chemical, physical, and biological traits that showed improvements from pre-restoration to post-restoration conditions. Funding, in many cases, restricted the extent to which project monitoring could be conducted and also influenced project scope and size (Pander, 2013). This often led to projects that lacked the capacity to conduct large-scale restoration and rigorous scientific monitoring. Consequently, CBWM organizations highlighted the difficulty of detecting the effects of small-scale projects, particularly at a watershed scale.

Where funding was available to conduct in-depth monitoring, CBWM organizations showed the capability to implement rigorous monitoring programs that tested a wide range of environmental parameters. Where standardized methods of assessment were available, such as for culvert assessments, CBWM organizations showed the willingness and ability to adopt and utilize these methods. Monitoring rigor decreased in projects with limited funding or funding that was specifically allocated for project action only. These projects often targeted known anthropogenic impacts that have been documented to have a high potential to degrade aquatic ecosystems. In these cases the impact was visual (e.g. erosion, riparian zone degradation, channelization, fragmentation), and the result of restoration action was evident. For these instances it can be shown that restoration action had mitigated the anthropogenic impact.

My research offers an overview of restoration activities being conducted by CBWM organizations in an attempt to protect freshwater environments from anthropogenic harm. It demonstrates that although restoration projects were successful in the mitigation or removal of targeted impacts, projects often lacked the corresponding water monitoring data required to track changes within the aquatic environment. My project is the first of its kind that utilized photographic documentation to discuss the process of conducting restoration projects with CBWM organizations. These findings present an important

insight into how restoration projects are planned and implemented with clear goals and objectives utilizing academic, professional, and regulatory expertise. Although documentation of how these processes transfer to restoration projects where observable ecosystem benefits are evident, the restoration process remains challenged by a lack of funding, capacity, and monitoring procedures that makes the existence of complementary water monitoring data representative of ecosystem benefits rare.

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## **Chapter 4: *Site Photos... Can Track Your Success: Evaluating the Application of Photo Elicitation for Assessing Environmental Restoration Project Impacts Through Planning, Process, Implementation, and Observation*<sup>3</sup>**

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### **4.1 Statement of Student Contribution**

C. Garda was responsible for all data collection and analysis, which this manuscript is based upon, as well as writing all sections. H. Castleden provided supervision for all stages of research and contributed to writing development and manuscript revisions.

### **4.2 Abstract**

Qualitative photo-research methods have been used for a wide range of empirical research, but to date cases where they have been used to assess the environment remain rare. This study looks at the application of the photo-elicitation research method to assess restoration projects that were conducted by community-based water monitoring (CBWM) organizations. Photo-elicitation interviews were conducted with 4 different CBWM organizations, with 8 participants. A total of 15 restoration projects were examined. Findings indicate that photo-elicitation is an effective methodology for assessing

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<sup>3</sup> This chapter has been formatted for submission as a "Practice-Based Knowledge" article to the journal *Society & Natural Resources*. According to this journal, Practice-Based Knowledge articles: "provide lessons learned from practitioners and academics working alone or together. Rather than attempting to test a hypothesis or establish new theory, what distinguishes practice-based articles is that they ground new insights into interactions between society and natural resources in particular places and actions, and provide clear descriptions of both the context and arrangements under which the work was conducted and what constitutes the data or evidence behind their assertions. We encourage submissions that reflect on why decisions, approaches to problem solving, practices, and ideas worked or did not work and how those lessons might be applicable to other contexts." Retrieved on Oct 17 2015 from: <http://www.tandf.co.uk/journals/authors/usnr-article-types.pdf>

restoration projects, and that interviews allowed for the documentation of both observable and measurable improvements within aquatic ecosystems. Other key findings show that photo-elicitation increased the clarity of interviews by the removal of misunderstandings caused by figurative language, elicited rich interview dialogue, and allowed participants to have partial control over the selection of subject matter.

### **4.3 Introduction**

Human activities are the leading cause in the deterioration of freshwater resources, a trend that has been documented at a global scale (Harper et al., 1998; Gleick, 2003; Jury & Vaux, 2007; Litvan, Stewart, Pierce, & Larson, 2008; Filoso et al., 2011). Aquatic ecosystems have been degraded by the alteration of stream flow, agricultural and industrial pollution, riparian zone removal, and the installation of structures that cause fragmentation within riverine systems (Harper et al., 1998; Maddock, 1999; Litvan et al., 2008), thus harming both water quality and biodiversity. In response to the deterioration of aquatic ecosystems an increasing amount of restoration projects are being conducted that attempt to counter damages caused by anthropogenic stressors (Kondolf & Micheli, 1995; Maddock, 1999; Lake, 2001; Palmer et al., 2005), with the last decade showing exponential growth in the frequency of these projects (Bernhardt et al., 2005).

As the application and practices of aquatic restoration continues to grow, it is apparent that there is a need to establish a scientific basis for how to implement successful restoration (Lake, 2001; Palmer et al., 2005; Wohl et al., 2005). Although there is general agreement amongst practitioners that restoration is important, progress has been hindered due to conflicting opinions amongst scientists on the criteria that must be used to evaluate successful restoration (Palmer et al., 2005; Wohl et al., 2005; Alexander & Allan, 2007). As this continues “*scientists and society must acknowledge that restoration decisions will continue to be made in the face of substantial scientific uncertainty, and thus there will continue to be a role for “qualitative” scientific judgments in informing restoration actions*” (Wohl et al., 2005, p. 7, emphasis added). Effective restoration methods must not only meet scientific criteria, but also need to be developed so they can be utilized

within the constraints of the practitioners that are instating the projects (Wohl et al., 2005). Thus begs the question: what methods might fit this dual purpose?

With this question in mind, the goal of this paper is to evaluate the application of photo-elicitation interviews for assessing environmental restoration project impacts. Photo-elicitation interviewing is a qualitative approach to research; its goal is to elicit responses from participants that are empirical in nature by using photographs as a communication medium during interviews (Harper, 2002). In this case, the method was applied to a study to document and assess the components of restoration projects being conducted by community-based water monitoring (CBWM) organizations within Canada. This paper looks at the adaptation of the photo-elicitation interview technique as a methodology: 1) for tracking the restoration process and understanding the factors involved in the process of planning, conducting, and completing restoration projects; 2) for identifying and documenting cases where CBWM organizations have implemented restoration actions that have led to observable or measurable benefits within aquatic ecosystems; and 3) for enabling participants to select and showcase activities that are meaningful to them by giving participants control over the selection of the subject matter while providing guidelines for the process.

## **4.4 Background**

### **4.4.1 Photography In Research (Photo Methods)**

The use of photographs in research interviews was first documented in Collier (1957 as cited in Loeffler, 2004), who used photographs taken by the research team in interviews with migrant workers to understand the migration experience of French-Acadian workers to an English industrial town. Collier found that interviews conducted with photographic aid elicited data that were richer and more informative than verbal interviews on their own. Colliers' approach was named 'photo-elicitation' as the method involved using photographs as a medium for collecting information during the interview process (Harper, 2002). Since then photography in research has been used in a number of

different ways. For example, in Wang and Burris (1994), the photo methodology was adapted such that control of the camera was placed into the hands of the research participants. This adapted methodology termed 'Photo Novella' allowed for the power dynamic to shift from the perspective of the researcher to that of the participant (Wang & Burris, 1994). Wang and Burris found strengths in this methodology as it showed its utility in "contributions to change in consciousness and informing policy" (p. 171).

The integration of photographs into interviews has been successfully implemented in qualitative research to explore a wide range of topics. Examples include a community-base participatory study on health and environmental issues with the Huu-ay-aht First Nations (Castleden et al., 2009), a study addressing cultural, social, and contextual factors that influence physical activity in Hispanic women (Fleury et al., 2009), an exploration of the values of community members within their community (Van Auken et al., 2010), an investigation into understanding irrigators' perceptions on water policy and development objectives in rural Australia (Keremane & McKay, 2011); and gaining perspectives on Australian farmers' values of tree cover on their land (Sherren et al., 2011).

Photography in research has also shown its utility for assessing environmental conditions, due to its ability to depict conditions at spatial and temporal timescales. Examples of some of the applications of photo methodologies in environmental assessment research are: using photographs to monitor the establishment and growth of willow communities for riparian zone assessment (Boyd, Hopkins, & Svejcar, 2006); the reconstruction of historical riparian conditions along river systems utilizing historical photos (McAllister, 2008); using photographs to assess the establishment of vegetation on road cutbanks in forested watersheds (Bold et al., 2010); and studying long-term trends in river channel and gully erosion using photographs that depicted the area of study over the course of 126 years (Frankl et al., 2011). Although these examples highlight research related to aquatic ecosystem health, to date my searches have found no documented cases of photo-elicitation interviews being employed to examine the restoration processes being implemented by practitioners. Thus exploring whether photo-elicitation interviewing is a

method that fits the dual purpose of scientific rigour and practitioner capacity makes sense as CBWM organizations often document their restoration activities through photography as a communication tool with regulatory agencies and the general public.

## **4.5 Case Context**

This paper reports on the methodological approach of a study that was conducted in Atlantic Canada working with 5 CBWM organizations from the provinces of Prince Edward Island, New Brunswick, and Nova Scotia; the overarching goal was to identify cases where activities conducted by CBWM organizations have benefitted the aquatic ecosystems being monitored. These organizations were all partners in the CURA H2O project (see curah2o.com), a community-university research alliance, funded by the Social Sciences and Humanities Research Council, developed to increase the capacity for CBWM within Canada and abroad.

## **4.6 Methods**

### **4.6.1 Participant Recruitment**

In 2013, 8 key informants representing 5 CBWM organizations were recruited from approximately 20 CBWM organizations that had partnered with the CURA H2O project based on the following criteria: (1) the CBWM organization was a current partner in the CURA H2O project; (2) the organization had a minimum of six years of establishment (to increase the likelihood that the organization would have sufficient data to contribute to the research study) (Leach, Pelkey, & Sabatier, 2002); (3) the organization had long term members who were involved with the planning of past and present restoration projects; (4) the organization maintained records of the activities that were conducted (e.g., photographs, project reports, and journal logs); and (5) water monitoring had been conducted throughout the existence of the organization.



Key informants, being persons who have in depth knowledge about their CBWM organization, that are actively involved with planning and logistic within their organization (McKenna, Iwasaki & Main, 2011), were recruited to participate in the study based on the following criteria: (1) they were a voluntary participant; (2) they were self identified, identified by members of the CBWM organization, or identified by members of the CURA H2O research team; (3) they were involved with the planning, organization, and implementation of CBWM activities and projects; (4) they had in-depth knowledge of past and present activities conducted by the CBWM organization and can provide details of the process; and (5) they were a primary source of information, e.g. directly involvement with the projects being discussed.

#### 4.6.2 Data Collection

Key informants participated in an initial semi-structured interview (Phase 1) to verify key informant status and identify subject matter that would be used in the second interview (Phase 2). The second interview, which took place a few weeks later, utilized a modified photo-elicitation interview to discuss the restoration activities conducted by the CBWM organization. Between the first and second interview, one participant withdrew, stating that their organization did not have projects matching the criteria requested for the photo-elicitation exercise associated with the second interview.

#### 4.6.3 Phase 1, Semi-Structured Interviews

Semi-structured interviews, ranging from 20-60 minutes, were conducted by phone and divided into 3 sections: introductory, exploratory, and participant driven. The introductory section focused on the CBWM organization and the involvement of the individual being interviewed. This section was used to verify the participation of key informants, and gain a general understanding of establishment of the CBWM organization and its mandate. The exploratory section focused on environmental problems faced by the CBWM organization within their watershed, identification of these problems, and any mitigation or prevention efforts being utilized to address them. From

the subject matter discussed, participants were asked if they could identify projects where the planning, implementation, and follow-up processes could be further explored during the photo-elicitation interview. The final portion of the interview was open-ended; this gave participants the opportunity to discuss any relevant topics that were not addressed by the interview questions.

#### 4.6.4 Phase 2, Photo-Elicitation Interviews

Based on qualitative content analysis of the Phase 1 interviews, a photo-elicitation guide (see Appendix I) was drafted and sent to participants. The guide provided further detail regarding the photo-elicitation methodology and instructions on how to prepare for the interview. The guide also made suggestions on some of the activities that could be used for the photo-elicitation interview based on the information provided during the Phase 1 interview. Activities were not limited to subject matter identified in the Phase 1 interview, and CBWM organizations were encouraged to include any additional projects that fit the research criteria. Each CBWM organization was requested to supply photographs of 3 to 5 activities that their CBWM organization conducted that had the potential to benefit the natural ecosystem. The photographs needed to depict the locations where the activities were conducted before, during, and after implementation.

The subsequent photo-elicitation interviews were conducted in person and ranged in length from 90-150 minutes. The average interview length was approximately 120 minutes. During the interviews each topic was discussed separately following a standardized question sequence. Photographs were laid out on a table so they were visible to both the participant and researcher. The question sequence for each activity was separated into 5 sections: general, planning, implementation, completion/follow-up, and participant driven. Under each of the main headings a primary open-ended question was asked about the activity. Supplementary questions existed for each of the open ended questions, but were only asked if the participant(s) did not address the subject matter in their answer. The interview was designed in this fashion to allow interviews to be fluid

and have as little interference or influence from the researcher as possible during the process.

The general section was designed to identify the type of activity being discussed, when it was conducted, the trigger for conducting the project, and whether the factor that triggered the project was a concern throughout the watershed. The lead question for this section was: what type of project/activity are we looking at? The second section of the interview focused on the planning process leading up to conducting the activity. This section focused on the planning process for the activity, parties involved in planning, how monitoring data was used in the process, and regulatory approval for the project. The lead question for this section was: would you be able to tell me about the planning process leading up to conducting this activity? The third section of the interview focused on conducting the activity, and how project work was completed. The only question asked for this section was: could you explain to me how this activity was conducted? The fourth section of the interview focused on project follow-up, success, and failure. This section focused on the completed project, whether the intended project outcome was achieved, observable benefits to the ecosystem, measurable benefits to the ecosystem, follow-up maintenance that was required, and any changes they would have made to the project. This section had 3 main questions: was any project follow-up required; what was working as intended, and what was not; and did the participants think that this activity benefitted the ecosystem, and if so what was the benefit? The fifth and last section was participant driven and allowed participants to freely discuss anything regarding the project that was not addressed.

#### 4.6.5 Data Analysis

To validate the accuracy of the transcriptions, transcripts were returned to participants so they could verify that the content within was correct (Baxter & Eyles, 1997). As the interpretation of transcription involves a form of translation, it is possible that context and meaning can be misrepresented during the process (Gibson, 2009). To address this, participants were provided with the opportunity to review quotations that would be used

in the final report and the context they were being used in. Interview data were analyzed using qualitative coding, where interconnected and like subjects were grouped by topic (Richards, 2005). Qualitative coding allowed for the identification of relationships and patterns within the data set (Richards, 2005; Tracy, 2013). A combined method of inductive and deductive data thematic data analysis was used to identify similarities, differences, and relationships between the topics identified within the interview transcripts (Gibson, 2009; Willig, 2013).

During the transcription of the Phase 1 interviews existing *a priori* codes of topics identified during the literature review and through consultation with the CURA H2O research team were identified and documented in a code list (Gibson, 2009; Whillig, 2013). The code list was used while reading transcripts line by line to deductively categorize identified themes under the pre-determined codes (Crabtree & Miller, 1999). Newly emergent themes that did not fall under any of the pre-determined code categories were identified and documented in the code list. An inductive approach was used to code the newly emergent themes where transcripts were read a second time (Kardorff, 2004; Tracy, 2013). The code list was continually updated throughout this timeframe to keep track of all *a priori* and emergent codes; the code list provided definitions for each of the codes (Tracy, 2013). Top tier codes that represented broad categories were classified as parent codes (Gibson, 2009). Subsequent codes, referred to as child codes, were then assigned under the corresponding parent code. This code list was used during the first round of coding of the Phase 2 transcriptions. Simultaneously, inductive coding was used to identify new emergent codes that existed within the Phase 2 interviews.

The evaluation of the photo-elicitation methodology used a combination of personal reflection and assessment based on Pauwels' (2010) 'integrated framework' for visual research. As the analytical focus of research will be dictated by the research questions (Pauwels, 2010), this evaluation focuses on the ability of the photo-elicitation methodology to answer the primary research questions: (1) are CBWM organizations conducting activities that lead to observable or measurable improvements within the aquatic ecosystem that are being monitored; and, (2) if so, what are these activities and

how are they being implemented? Evaluation consisted of assessing the ability of the photographs to visually depict the subject matter being discussed (Rose, 2001; Kong et al., 2015), (i.e. restoration activities), and the quality of information provided when photographs were paired with semi-structured interviews (Kong et al., 2015). Quality in this regard relates to the ability of the information to inform and answer the research questions.

#### **4.7 Evaluation on the Use of Photo-Elicitation Interviews in Environmental Restoration Impact Assessment**

The substantive findings from this research (see Chapter 3) suggest that photo-elicitation interviews are an effective way to assess the impacts of environmental restoration projects. The interviews created an opportunity to document projects that led to both observable and measurable benefits within aquatic ecosystems. The photographs served as points of reference where participants could base their evaluations and ensuing descriptions around the visual images that depicted the different project stages (Gold, 2004). The pairing of photography with interviews allowed for aspects of projects to be discussed with visual representation that would not be possible with a standard interview. This provided a measure of clarity and understanding within the interview when discussing before and after project conditions, project scale, and specific project stages. By allowing participants to select the activities that were being discussed and the photographs that depicted these activities, the photo-elicitation method allowed participants to describe and showcase projects that were meaningful to them.

A total of 23 projects were describe during Phase 2 of the study, with 15 projects matching the desired research criteria of being a complete restoration or enhancement project. The 8 remaining projects were still in the planning phase, or public education, staff training, and ongoing monitoring programs. Although relevant, these projects did not provide an opportunity to compare and contrast the stages of a completed process and are not discussed herein. In 12 of the 15 restoration projects assessed, CBWM organizations were able to provide photographs that documented the site conditions

before, during, and after a project was conducted. The number of photographs provided for each stage (before, during, after), ranged from 1-10 photos. In 14 of the projects a standardized procedure was not used to take the photos, although participants indicated that they had attempted to take photographs from similar locations. In 1 project, standardized photo locations were established where photographs were periodically taken throughout the project. In this case, the photographs were able to illustrate the progression of the project and changes that occurred in significant detail. It is to be noted that the photographs provided for each of the projects were pre-existing; none of the photographs were taken for the purpose of the photo-elicitation study. The use of photographs gave the interview a focused and natural flow. Interviews shifted chronologically through photographs as the interview progressed and used the photographs to frame the discussion. Photographs acted as timestamps, points in time at which both researcher and participant could orientate themselves.

Photographs taken of pre-project conditions were able to clearly illustrate project locations and the environmental condition that triggered the need for restoration action. This can partially be attributed to a majority of the projects addressing impacts that were visual in nature, such as erosion and sedimentation, in stream structures, and riparian zone conditions. In these applications, photographs served as benchmarks capable of illustrating the condition of the location in more detail and accuracy than could be depicted through verbal descriptions alone. Photographs also allowed for participants to discuss projects from a documented point of reference instead of relying entirely on memory.

Each topic discussed in the interview began with participants telling the history of the location that led to the point depicted in the first photo. For example, when discussing a sedimentation prevention project the participant was asked to identify the type of project that was identified in the photographs. The participant's response began with: *"In the late fifties early sixties two local companies started two pits... Both of these pits were dug because of the nice river rock there [...] for construction purposes. So what the pictures we're looking at on the table, there, are [showing is] [the] pit. So they operated them up*

*until [the] early 80s and then abandoned them and basically walked away.*” (P-01). In an interview with another CBWM organization, when inquiring about a dam removal project, after giving a brief synopsis of the whole project the participant began talking about the history of the structure. *“It was originally a secondary water supply for CFB [ ] when it was still an active military base. ... I’m going to say it was built in the fifties, it may have been in the thirties.”* (P-08). From that point, the participant talked about the historical uses and ownership of the structure up to the point depicted in the first photograph in the sequence - the dam - when the CBWM organization took on responsibility for removal of the structure. These responses added a depth of historical context to the interview that was not directly asked in the interview questions. This provided background on not only what the anthropogenic concern was, but the history of how and why the factor depicted in the photograph existed.

The interview alone would have been sufficient to identify the reason for implementing the project, funding sources, preliminary assessment procedure, people involved in planning, monitoring data used, project restraints, and the project approval process. As a majority of the planning process is non-visual, photographs had little impact on this portion of the interview. The majority of the information provided came from allowing participants to speak freely about the process. But, participants did use photographs to describe the physical project location, site assessment procedures, and people who were involved in project planning.

The photographs provided to depict the progression of work throughout the course of restoration action were the most variable and intermittent. This reduced the ability of the photo-elicitation methodology to assess this stage of the project, and is attributed to this stage of a restoration project often having rapid change in site conditions as opposed to a project’s start and end points where change is gradual or not occurring. Also, as the practitioners conducting the work were responsible for taking photographs, these photos were often limited to significant stages in the project or opportunities such as break periods when photos could be taken. These photographs illustrated projects at a specific point in time and relied on verbal dialog to fill in the gaps between photos. This segment

of the interview was strongly focused on verbal explanation of the process used to conduct the activity, and photographs aided in explain actions, procedures, project stages, scale, and providing clarification (Figure 4.1).

*“In picture #7 you can actually see the children get to handle the fish, so it’s more of a hands on component and they get to see up close the differences between different species.”* (P-06) (Figure 4.1a.)

*“The hay bale was set at the bottom in order to actually try to prevent the mobilization of the silt and sediments.”* (P-02) (Figure 4.1.b.)

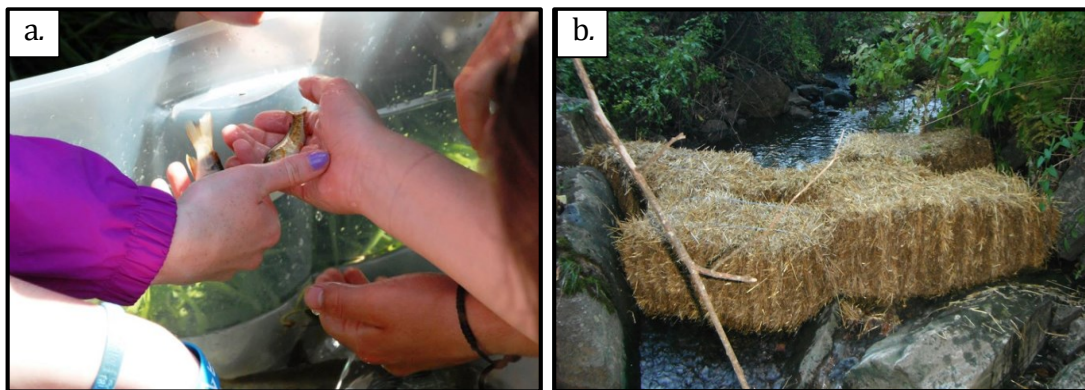


Figure 4.1: a) a photograph used to depict and explain a step in the process of electrofishing with school children; b) hay bales placed downstream of the project work site to prevent the transport of sediment.

The final portion of the interview examined the completion and outcome of the project and any follow-up action that was required. Participants used photographs to compare and contrast conditions at project locations before and after work was conducted, and were able to illustrate observable improvements in site conditions. Participants identified the aspects of the project that: indicated project success, supported monitoring results, identified where maintenance work was required, and suggested changes they would like to have made in project design and learning outcomes that would aid them in future projects.



*“Yes, [the project was successful] and again, from the aesthetics going from something that is horrible to something that at least looks like what you would expect out of an urban waterway. The fish passage is the biggest thing. There is no way fish were getting through here before, only during high water. And of course, when there was high water the flow was such that fish would have no way to get through there anyway. And now we have more of a natural stream.” (P-02)*  
(Figure 4.2)



Figure 4.2: Culverts in a feeder brook a) pre-removal, and b) post-removal.

After each project was described, participants were given the opportunity to address any additional information that was not already covered. Participants often stated that there was no additional information to discuss, indicating that the photo-elicitation method was able to cover the full scope of the project.

#### 4.7.1 Methodological Strengths

The photo-elicitation interview technique allowed participants and researcher to easily identify the primary factors that enabled and restricted the restoration projects conducted by the CBWM organizations. Interviews were free flowing with minimal interruption by the researcher throughout the process. The use of photographs provided an opportunity for rich clarification of the topics being discussed and created a standardized frame of reference between the researcher and participant. Photographs removed the confusion and misunderstanding caused by the use of figurative or ambiguous language within interviews, such as when discussing size or scale, in reference to the condition of a

structure, or when explaining the physical state of a location. For projects that impacted physical conditions, photographs were able to provide a clear contrast between site conditions before and after the project was conducted (Figure 4.3 a & b), allowing for their use as both communication and assessment tools.

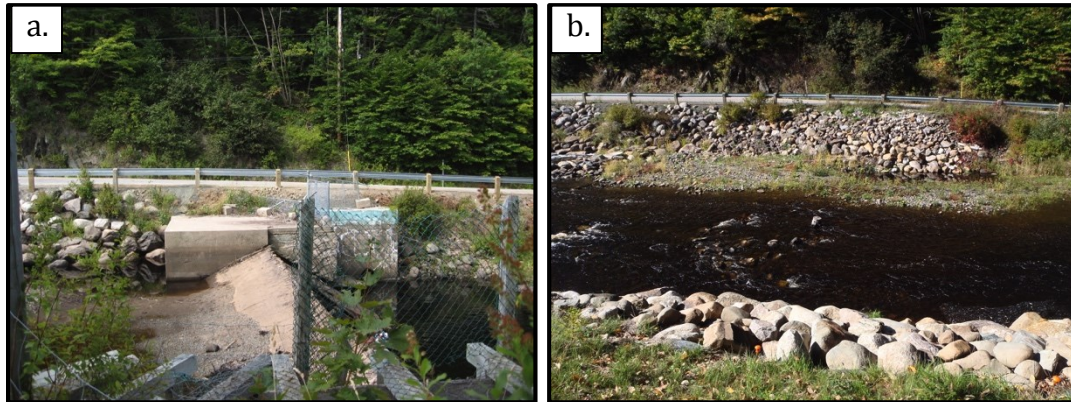


Figure 4.3: Removal of an in-stream dam, a) pre-removal, and b) post removal.

#### 4.7.2 Methodological Weaknesses

A key issue that influenced the quality of this research was the selection, availability, and quality of photographs. As the projects discussed were all completed, it was necessary to use existing photographs for each. Many of the CBWM organizations did not have a standardized photographic protocol to document the project from start to finish. Although in a majority of the projects CBWM organizations were able to supply photographs of the project area before, during, and after work was conducted, the quality, location, and imagery depicted in the photographs varied making it, at times, difficult to achieve the rigour that many professionals (i.e., trained and paid) scientists would deem necessary.

### 4.8 Discussion

Photo-elicitation can be a valuable method for understanding the processes and outcomes of restoration projects and documenting cases where CBWM organizations' activities have influenced positive environmental changes within the ecosystems in which they

operate (Conrad & Hilchey, 2011). Photographs as a source of data-elicitation through interviews provides a medium that engages both the researcher and participant in ways that promote the development of shared understandings and new knowledge (Wang & Burris, 1997; Foster-Fishman et al., 2005). My searches found no other documentation of this technique being adopted in order to assess aquatic or other environmental restoration projects, despite many restoration projects undergoing substantial visual transformation. The following discussion will focus on the adaptation and application of the photo-elicitation interview technique in order to assess environmental restoration and enhancement projects and the limitations of this technique in this application.

#### 4.8.1 Adaptation and Application of Photo-Elicitation

Originally and more typically, photo-elicitation interviews have used photographs taken by or selected by the research team (Collier, 1957; Harper, 1986), although more recent, adapted versions of the technique have utilized photographs that were taken by participants (Loeffler, 2004). Due to the nature of the projects being discussed within this research, the photo-elicitation interview technique was adapted to utilize existing photographs of restoration projects that had been taken by participating CBWM organizations. This modification can be differentiated from previous techniques as, in this case, participants selected photographs from their own databases but did not necessarily take the photographs. For the assessment of restoration projects this process is recommended as long as the participants had in-depth involvement in the project planning and implementation process. None of the participants had problems recalling the subject matter depicted within the photographs, regardless of whether they took the photograph or not. Moreover, while participants were responsible for choosing their own content and subject matter, they were guided in the process by the research criteria for project selection. This created a shared dynamic between researcher and participant in the selection of projects and photographs that were used in the research. Although participants were guided in the selection of project types and photographs, the ultimate choice of topics and photographs used was placed in the hands of the participant. This ensured that the topics being discussed were of importance to the participants and

allowed them to showcase projects that were meaningful to them. This selection process aided in the removal of bias by the researcher, but contributed to the selection of 8 projects that did not match the predetermined research criteria. These projects could not be included in the data analysis.

#### 4.8.2 Limitations and Implications

Earlier research emphasized that photographs are only able to depict the physically observable, and this can lead to a lack of representation of subject matter that cannot be photographed (Gregory, 1994). More recently, research has shown that photographs are capable of eliciting responses of content that is not directly depicted, or that is metaphorically represented within the photograph (Castleden et al., 2008; Van Auken et al., 2010). The second statement held true when using photo-elicitation to assess restoration projects in my research as the photographs were used to talk about an entire process and not just a singular point in time. However, the limitation of representation expressed in Gregory (1994) was encountered when selecting projects for Phase 2 interviews. Project selection was limited to cases where anthropogenic stressors had already occurred within the aquatic ecosystems, as restoration is not required in ecosystems that exist in a natural state. This limits the photo-elicitation methodology to assessing projects where anthropogenic stressors have occurred and are observable in nature, and excludes cases of prevention. Prevention of anthropogenic harm is recognized as the most effective strategy for the protection of aquatic ecosystems (Beechie et al., 2008). Photo-elicitation is unable to assess the implications of prevention as the successful implementation of this strategy would lead to no change within the aquatic ecosystem.

The photo-elicitation methodology allowed for detailed discussion regarding the planning, implementation, and outcome of the projects, but had limited capacity to pair interview results with analytical water monitoring data. The main factors that attributed to this were a lack of project specific water monitoring data, and monitoring data that required analysis beyond the capacity and scope of my research. Whereas all of the

CBWM organizations that participated in this study conducted monitoring at a watershed scale, the analysis of these data sources would involve significant amounts of data entry and statistical analysis. Any changes detected at a watershed scale would be difficult to attribute or link to small-scale restoration or anthropogenic stressors. In my research the photo-elicitation methodology was applied to activities associated with restoration projects that were already completed. Building the photo-elicitation interview technique into projects from the start would create a visually explicit and comprehensive data set particularly for rigour as the methodology could be standardized. This would ensure that projects would have adequate photo-documentation during all stages. Photographs are capable of capturing the condition of a project area before, during, and after work is conducted. Increasing the quality, location, and imagery depicted in the photographs could be beneficial for the professional science-CBWM organization relationship and advancing the understanding of restoration activities. This could be achieved by ensuring that photographs are taken from standardized locations using the same focus and angle throughout projects. Series of photographs taken using this method would allow for a true time-lapse comparison of project conditions.

## **4.9 Conclusions**

In order to facilitate the progression of scientific understanding of how to conduct successful restoration projects it is necessary to understand the factors that influence them. These factors should include both quantitative monitoring data and quantitative analysis that identifies the constraints faced by practitioners. Photo-elicitation provides an excellent medium by which to study the qualitative aspects of restoration projects, and can be expanded on to include quantitative monitoring data. Photo-elicitation interviewing provides a medium that can be used to examine restoration activities, document cases of successful restoration, and understand the processes and factors that enabled it. It is recommended that further applications of the photo-elicitation methodology be utilized to assess a variety of monitoring and restoration projects. To build on the understanding of the utility of this technique, projects would ideally

incorporate photographic protocols from the beginning of the project and allow for project specific water monitoring data to be collected.

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## **Chapter 5: Discussion and Conclusion**

### **5.1 Introduction**

Due to concerns over water quality and aquatic ecosystem health, a growing number of citizen science CBWM organizations have been established and have tasked themselves with monitoring aquatic environments and promoting environmental stewardship initiatives (Whitelaw et al., 2003) such as restoration. The growth of CBWM in Canada corresponds to a timeframe where declines in government funding have limited the ability of government departments to collect environmental monitoring data (Vaughan et al., 2003; Pollock & Whitelaw 2005; Sharpe & Conrad 2006; Kebo & Bunch, 2013; Winegardner et al., 2015), and legislative changes have weakened the protection of Canada's freshwater resources (Kirchhoff & Tsuji, 2014; Winegardner et al., 2015). Despite the growth of CBWM organizations conducting watershed monitoring and restoration globally, and within Canada, there remains a gap in the academic literature regarding the benefit, if any, that CBWM and associated activities provide to natural ecosystems (Conrad & Hilchey, 2011). Therefore, to begin to address this gap my research sought to identify and document cases where activities conducted by CBWM organizations have benefitted the aquatic ecosystems being monitored. This chapter restates the overarching research questions and objectives, highlights and summarizes the key findings, and expresses recommendations for CBWM organizations and future research.

### **5.2 Addressing the Research Objectives**

#### **5.2.1 Overview of Research Objectives and Methodology**

Using a qualitative multi-case study approach, my research was guided by the following research questions.

1. Are CBWM organizations conducting activities that lead to observable or

measurable improvements within the aquatic ecosystems that are being monitored?

2. If so, what are these activities and how are they being implemented?
3. Is the photo-elicitation methodology capable of assessing restoration projects, and what are the strengths and weaknesses of this application?

To address these questions, I identified 5 main research objectives.

1. Identify and document actions conducted by CBWM organizations that have the potential to benefit the natural ecosystem;
2. Obtain in-depth information regarding the planning, implementation, and follow-up stages of the actions identified, to use for data analysis;
3. Identify cases where monitoring and restoration activities have led to positive observable or measurable ecosystems responses;
4. Identify the factors that enable success, and challenges that impede success; and
5. Evaluate the photo-elicitation methodology to determine if it is an appropriate methodology to use for the assessment of restoration projects.

In Phase 1, interviews were held with members of 5 CBWM organizations within Atlantic Canada to identify actions conducted by the organizations that had the potential to affect the natural ecosystems (Objective 1, Research Question 1). In Phase 2 in-depth interviews were conducted with 4 of the CBWM organizations that allowed for in-depth discussion of the planning, conducting, and follow-up to the actions identified in research Phase 1 (Objective 2, 3, and 4, Research Question 1 and 2). After the interview sessions, monitoring data for the activities discussed was requested from the CBWM organizations if applicable (Objectives 2 and 3, Research Question 1 and 2), a majority of the projects discussed did not have corresponding aquatic ecosystem monitoring data. An evaluation of the photo-elicitation was conducted (see Chapter 4) that verified that the methodology

is an appropriate technique for assessing restoration projects (Objective 5, Research Question 3).

### **5.3 Key findings**

My study identifies 6 key findings.

1. CBWM organizations are actively conducting restoration projects that, based on observation, are mitigating or preventing further anthropogenic harm to aquatic ecosystems.
2. There are many examples of observable ecosystem improvements but examples of tangible measurable responses within aquatic ecosystems remain rare.
3. The process of restoration involves baseline monitoring, engagement with resource management agencies, regulatory approval, expert consultation, and project reporting.
4. The primary triggers for CBWM organizations' actions were visual monitoring and long-term knowledge of watershed conditions.
5. The implementation and identification of 'successful' restoration is hindered by the current monitoring and restoration project funding structure, access to private land, and lack of understanding and agreement within the scientific community about what constitutes successful restoration.
6. The photo-elicitation technique proved to be useful for assessing and identifying the observable benefits of restoration projects.

The following section discusses each of the key findings in relation to relevant literature.

#### **1. CBWM organizations are actively conducting monitoring and restoration projects that mitigate or prevent further anthropogenic harm to aquatic ecosystems**

A majority of the monitoring and restoration projects discussed were conducted in response to anthropogenic influences that have been documented to degrade aquatic

ecosystems. Out of 15 projects, 5 projects focused on restoring habitat connectivity and 4 projects focused on sediment control and riparian zone restoration. In the hierarchical approach proposed in Beechie et al. (2008), restoration projects should be selected based on the probability of success, response time to the action within the natural ecosystem, and the longevity of the project type after implementation. Projects that target anthropogenic factors known to degrade the quality of aquatic ecosystems can prevent further ecosystem harm and provide the system with an opportunity to naturally repair itself (Kauffman et al., 1997; Jähnig et al., 2010; Ruwanza et al., 2013). Primarily, action should be taken to protect high quality habitat within watersheds, as not allowing habitat to become degraded in the first place provides greater ecosystem benefit than the restoration of degraded habitat (Kauffman et al., 1997; Roni 2002; Beechie et al., 2008). The second priority of restoration should focus on the reconnection of isolated habitats and the prevention of habitat fragmentation (Beechie et al., 2008; Roni et al., 2008). And lastly, restoration should focus on processes that create and sustain habitat (e.g. streamflow, water quality, sedimentation, and riparian zone health) (Beechie et al., 2000; Bohn & Kershner, 2002; Roni, 2002; Beechie, 2008).

Five of the projects examined during this study focused on reconnecting fragmented habitats caused by in-stream structures that prevented fish passage. Four of the projects focused on processes that create and sustain habitat. The projects demonstrated a high probability of success, as their main objective was to mitigate anthropogenic influences. Further, they displayed relatively short response times: habitat was reconnected instantaneously after blockages to fish passage were removed; and bank stabilization and riparian zone restoration halted sedimentation and bank erosion within a short timeframe. After implementation most of the projects were self-sustaining, which demonstrates longevity.

**2. There are many examples of observable ecosystem improvements but examples of tangible measurable responses within aquatic ecosystems remain rare**

Many of the restoration projects demonstrated observable improvements, but cases of measurable improvements in physical, chemical, or biological indicators remain rare. In multiple restoration projects, observable changes in site characteristics were evident, but data seldom supported measurable responses within aquatic ecosystems due to restoration action. Factors contributing to this were a lack of project specific monitoring data, and individual projects being conducted at a small-scale where the detection of change would be extremely difficult with the watershed-scale monitoring processes being implemented. When discussing projects, it was evident from photographic documentation of pre- and post-project conditions that anthropogenic impacts that have the potential to degrade aquatic ecosystems were being mitigated. This was clearly observable for sediment prevention, riparian zone restoration, and connectivity projects. Pictures were also able to identify cases where restoration actions led to the stabilization of sedimentation sites, the recovery of riparian zones, and the reconnection of isolated habitat; this was also confirmed within the verbal interview data.

In 3 of 5 of the habitat connectivity projects standardized procedures were used to evaluate fish passage through in-stream structures based on provincial and/or federal standards or guidelines. Physical measurements were utilized before and after conducting projects to ensure that structures allowed for fish passage within the watershed. Although these projects are capable of documenting the reconnection of habitat, they were not paired with comprehensive fish population surveys to evaluate the dispersal of fish throughout the system. The one project that had evident observable and measurable ecosystem responses was the removal of a dam that blocked connectivity within a river system. This project was notably larger than the other projects discussed, and it is expressed in the literature that large-scale projects provide the greatest potential for detecting changes caused by restoration (Shields et al., 2003). The main characteristics that differentiated this project from the others discussed were: it was large-scale in comparison to other projects; and the private non-government funding source not only promoted pre- and post-project monitoring, it stipulated that a portion of the funding was specifically for this task.

### **3. The process of restoration involves baseline monitoring, engagement with resource management agencies, regulatory approval, expert consultation, and project reporting**

Within the literature, steps highlighted to increase the likelihood of project success are: clear project goals and objectives (Dahm et al, 1995; Kondolf, 1995; Lake, 2001; Palmer et al., 2005; Jähnig et al, 2010); the collection of baseline data and pre-restoration conditions (Kondolf, 1995; Chapman, 1998; Lake, 2001; Palmer et al., 2005; Bernhardt & Palmer, 2011); and clear reporting or documentation of the outcome (Lake, 2001; Nienhuis et al., 2002; Palmer et al., 2005; Pander & Geist, 2013). All of the examined projects were guided by clear goals and objectives that identified the desired end result of each project, and a strategy on how to achieve this. Ten of 15 projects required a regulatory approval process, and utilized expert consultation provided by regulatory staff, academics, and professionals in the restoration field in the project-planning phase.

Each of the CBWM organizations that participated in this study have been involved in the collection of baseline monitoring data throughout the course of their existence. All CBWM participants conduct routine water monitoring of physical and chemical parameters within their watersheds from established sampling locations, which are used to track water quality trends. Four of the 5 organizations conducted benthic macroinvertebrate sampling within their watershed, and 3 organizations participate in the Canadian aquatic biomonitoring sampling program. Additionally, all CBWM organizations conducted routine visual assessment surveys within their watersheds where physical conditions within the watershed were assessed. This allows for them to assess for and document changes within their watersheds over time.

Although standardized baseline water quality monitoring existed in all watersheds it was not designed to be project specific, and was conducted at a watershed scale. None of the participants identified changes in water-quality or benthic macroinvertebrate communities in non-project specific data sets due to restoration actions. In the case where changes were evident, project specific monitoring was conducted. For all projects discussed,

visual site assessment and changes in physical site conditions were able to document significant changes on each of the project locations from pre- to post-restoration.

Post project reporting was conducted on 13 projects, with 10 reports submitted to regulatory agencies, and 7 reports made publically available. As indicated in the literature, project reporting is one of the major components of a successful restoration project as it allows for the transfer of knowledge amongst practitioners (Lake, 2001; Nienhuis et al., 2002; Palmer et al., 2005; Pander & Geist, 2013).

#### **4. The primary triggers for action were visual monitoring and long-term knowledge of watershed conditions**

The primary triggers for the identification of restoration projects were visual monitoring and long-term knowledge of watershed conditions. Twelve of the projects discussed during this study were identified during routine watershed surveys or by public reporting to the CBWM organization. Only 3 of projects were initially triggered by water-monitoring data that detected changes in water quality between established upstream and downstream monitoring locations. Visual assessment was an important tool in identifying project locations, as it triggered more in-depth assessment to be conducted for sedimentation sites, riparian zones, and barriers to connectivity.

#### **5. The implementation and identification of ‘successful’ restoration is hindered by the current project funding structure, availability of land, and lack of understanding and agreement within the scientific community**

With the current project funding structure – federal, provincial, and other sources – it is much easier to obtain funds for project action than it is to receive funding for project monitoring (Kondolf, 1995; Wohl et al., 2005; Sharpe & Conrad, 2006). Funding often stipulates, quite specifically, that it must be used for conducting projects, meaning that organizations cannot allocate a portion of the funding for monitoring. This often leaves CBWM organizations with the difficult choice of allocating their already limited funds



towards project monitoring, that may or may not be able to detect ecosystem responses, or using these funds to support projects that mitigate or prevent known anthropogenic impacts. As most of the restoration actions are conducted on a small-scale, monitoring on numerous small-scale projects would take up a large amount of CBWM organizations' funds and capacity due to travel requirements and limited numbers of staff. In 12 of the projects analyzed during this study, projects were dependent on outside funding sources and in-kind contributions that influenced and limited the scope of the project. Without set criteria for implementing successful restoration, and funding models that incorporate funds for pre- and post-project monitoring, there is limited incentive for practitioners to monitor and report on restoration outcomes (Palmer et al., 2005).

Another factor that restricted the implementation of restoration projects is access to the land. This is most problematic in watersheds where the vast majority of land is privately owned, and CBWM organizations are dependent on landowner permission in order to target locations of concern within the watershed. Restricted access to land limits restoration in 2 main ways: first, projects are more likely to be conducted on a small-scale that causes fragmentation in restoration efforts and makes the monitoring of ecosystem responses more difficult; second, projects may not be able to target the areas where the greatest concern for anthropogenic stressors exist.

Lastly, there is a need to establish a scientific basis for processes that allow for the implementation of successful restoration (Lake, 2001; Palmer et al., 2005; Wohl et al., 2005). There is agreement amongst scientists and practitioners alike that restoration is important, but there are conflicting opinions on the processes required to implement and track restoration projects to determine project success (Roni et al., 2002; Palmer et al., 2005; Wohl et al., 2005; Alexander & Allan, 2007). This is further confounded by the complexity of aquatic ecosystems, where (1) there exist multiple relationships between physical and chemical processes, and (2) how these relationships influence biodiversity and habitat are not fully understood (Kondolf, 1995; Graf, 2001; Pess et al., 2003; Wohl et al., 2005).

## **6. The photo-elicitation technique proved to be useful for assessing and identifying the observable benefits of restoration projects**

The photo-elicitation technique proved adept at assessing restoration projects when photo documentation of the project is available. Interviews were able to fully cover each of the projects discussed, using photographs as a medium that displayed physical site conditions. Pairing photographs with the interview process removed the confusion and misunderstanding cause by figurative language on aspects such as size and scale or when describing the physical state of a location. Photographs allowed for physical comparison of site conditions pre- and post- restoration, where visual benefits to site could be observed. The technique proved useful for answering the primary research questions posed in my research.

Challenges associated with the photo-elicitation technique are apparent when limitations in data are encountered. Only projects with photographic documentation could be assessed using this method. Also, my research had limited capacity to pair qualitative, measurable water monitoring data with the projects being discussed. This was due to a lack of project specific water monitoring data for a majority of the projects. Although, all of the participating CBWM organizations conducted water monitoring at a watershed scale, monitoring at this scale would be unlikely to detect changes from small-scale restoration and analysis of this data source was beyond the scope of my research.

### **5.4 Limitations**

This section highlights limitations and challenges, discusses how I overcame them, and how they influenced my study.

One of the significant factors that shaped my research was the primary research question that sought to identify observable *and* measurable changes within aquatic ecosystems caused by CBWM organizations. This immediately excluded many of the activities that

are conducted by CBWM organizations that could benefit aquatic ecosystems both directly and indirectly, because they are extremely difficult or impossible to observe or measure. Two examples identified during the study that were difficult to measure or observe were the CBWM organizations' educational outreach and prevention activities. All CBWM organizations that participated in this study were actively involved in public education outreach programs that reach large amounts of people within their communities. Some organizations had partnerships with local school systems, where part of the curriculum entailed educating students about aquatic ecosystem health, monitoring, and fish life cycles. These programs had both classroom and hands-on field components, and likely contributed to building social capital regarding watershed health within these communities.

In cases where CBWM organizations prevented development projects or activities that would have adversely affected aquatic ecosystem health, there is no basis to determine what the effect on the aquatic ecosystem would have been, or how the system would have reacted; prevention has no observable or measurable outcomes. In the hierarchy of protecting aquatic ecosystems, prevention is the most beneficial as it is the only action that is 100% effective at saving aquatic environments from becoming degraded.

This study also encountered limitations in data interpretation. While the CBWM organizations that participated in the study had long-term monitoring data sets, due to the time and resource limitations of my own research it was not possible to compile and analyze their long-term monitoring trends, which may have shown improvements or declines in water quality parameters. Although improvement or decline in water quality at a watershed scale would be difficult to relate to the limited number of activities discussed during the study, data that correlated to specific projects may have been available for interpretation.

Lastly, limitations in inclusion criteria for both CBWM organizations and the activities assessed during the research decreased the robustness of the study. CBWM organizations were chosen from existing CURA H2O partners, a relatively small sample pool of

approximately 20 organizations at the start of the project. This sample pool was based in Atlantic Canada, thus excluding numerous CBWM organizations throughout Canada. The rationale for this decision was based on the close relationship that these organizations had with the CURA H2O research team, and the in-depth knowledge that the CURA H2O research team had about each organization that aided in the selection of CBWM participants; this aspect is discussed further in the challenges.

Quite early during the literature review, it became apparent that there was an abundance of literature focused on aquatic ecosystem health. The challenge, however, is that this body of literature has diverse perspectives about the steps required to document, track, and prove cases of successful restoration that are leading to benefits to the aquatic ecosystem. As highlighted through my study there is agreement amongst the scientific community that restoration is important, but there is no agreement on the processes or monitoring procedures required to prove that restoration was successful (Roni et al., 2002; Palmer et al., 2005). This is further confounded by a lack of scientific understanding of the interactions between physical and chemical processes, and their influence on biodiversity within aquatic ecosystems (Kondolf, 1995; Graf, 2001; Pess et al., 2003; Wohl et al., 2005).

I attempted to address potential research bias by incorporating a broad range of literature into the study. Common themes that were apparent throughout the literature were given a higher consideration when assessing projects conducted by CBWM organizations. Common themes included: clear project goals and objectives (Dahm et al, 1995; Kondolf, 1995; Lake, 2001; Palmer et al., 2005; Jähnig et al, 2010); the collection of baseline data and pre-restoration conditions (Kondolf, 1995; Chapman, 1998; Lake, 2001; Palmer et al., 2005; Bernhardt & Palmer, 2011); and clear reporting or documentation of the outcome (Lake, 2001; Nienhuis et al., 2002; Palmer et al., 2005; Pander & Geist, 2013). Another common theme is that restoration activities should be strategically targeted to prioritize the preservation of high-quality habitat, reconnection of habitat, and restoring processes that maintain and create habitat (Kauffman et al., 1997; Roni et al., 2002; Beechie et al., 2008; Roni et al., 2008).

As the primary research question states, the goal of this study was to identify activities conducted by CBWM organizations that could be associated with observable or measurable improvements within the ecosystems being monitored. In the beginning, the potential activities were categorized into prevention, mitigation, education, and restoration. Throughout the literature review, and while conducting the Phase 1 interviews, it became evident that activities such as prevention (e.g. preventing an adverse impact from ever occurring) and education would be extremely difficult to assess in terms of observable or measurable ecosystem improvements. From the data collected in the Phase 1 interviews, it was determined that the primary focus of the study would be on restoration activities, as these would provide the greatest opportunity to assess observable and measurable ecosystem improvements. Based on the information provided during the Phase 1 interviews, an information sheet was prepared individually for each CBWM organization that explained Phase 2 (photo-elicitation) of the research, and provided guidance for the selection of activities to discuss in-depth during the interview. Although never explicitly stated, the guide did have a main focus on the selection of topics that would be considered restoration projects. During the selection of activities for Phase 2 interviews, I provided guidance to CBWM organizations for the selection of activities, but did not dictate to organizations in terms of what activities to choose even when this decision-making process was being asked of me by 2 of the participating organizations. I ultimately left the selection of activities up to CBWM organizations, as I believed that this would allow the participants to select activities that were important and meaningful to them. Upon conducting the Phase 2 interviews it was evident that there was confusion with my instructions as some of the topics chosen were of baseline monitoring programs, staff training, community recognition awards, and educational outreach programs; these activities did not necessarily have planning, conducting, and follow-up stages that were observable or measurable. Although these topics were important, they often included little information relating to the original research questions, and offered a subset of information that was outside of the scope of research. From these topics it was a difficult choice to exclude information from the primary study, but was necessary when the information did not relate to the topic. At the same time, in

order to not lose the richness of the data provided from these topics, aspects have been included in the future research section of this thesis.

## **5.5 Research Contributions**

### **5.5.1 Methodological Contributions**

The ‘photo-elicitation’ technique applied in my research was unique for assessing environmental projects. Photo-elicitation is a tool that allowed for the visual aspects of restoration projects to be depicted, and facilitated in-depth discussion regarding the restoration projects chosen for the study. Photographs, as a source of data in the interview process, provide a medium that helps build understanding of the topics being discussed. Photographs engage both the researcher and participant in ways that promote the development of knowledge (Wang & Burris, 1997; Foster-Fishman et al., 2005). Project imagery provided a clear depiction of projects pre- and post-restoration, allowing for before and after conditions of the projects to be compared and contrasted. Also, the use of photographs removed the potential of misunderstandings caused by figurative language (e.g. discussing size or scale, in reference to the condition of a structure, or when explaining the physical state of a location).

One inherent weakness of photographs is that they are only able to depict what is visible. The photo-elicitation technique compensates for this by utilizing an interview structure that asks about the planning, conduction, and follow-up processes for each project discussed. In this aspect, photographs become timestamps, a common reference point between researcher and participant, in the chronological discussion of each restoration activity. The application of photo methodologies shows promise for both researchers and practitioners in examining and documenting aspects of restoration projects.

### 5.5.2 Substantive Contributions

This thesis offers new knowledge regarding CBWM with respect to how monitoring and restoration activities are being used to protect and improve aquatic ecosystem health. Given the absence of documented cases of how the activities of CBWM organizations contribute to improvements in aquatic ecosystem health within academic literature, my research was able to identify and document cases where observable and measurable improvements were evident due to actions conducted by CBWM organizations. My study emphasizes the need for advances in scientific understanding of aquatic ecosystems and monitoring processes to facilitate improved success rates for restoration projects, and for funding structures that allocate resources for project monitoring. My research also shows a disparity between the amount of restoration projects that provided observable ecosystem benefits and those that are able to provide monitoring data capable of detecting responses within aquatic ecosystems.

## 5.6 Recommendations

Based on my review of the literature and the research conducted for this thesis, the following recommendations target the development of more robust restoration and monitoring procedures.

1. Monitoring processes that are capable of tracking responses to restoration action within aquatic ecosystems should be developed. These processes should be developed with collaboration between government, academics, and CBWM organizations. The targeted outcome should be based on an understanding of what is transferable to real world monitoring and restoration scenarios. No matter how applicable a monitoring technique is, if volunteer organizations that are actively conducting restoration work cannot implement the technique due to cost, level of expertise, time commitment, and so on, then the functionality of the method is compromised. Currently it is easier to monitor the response of aquatic ecosystems to larger scale projects, but methods also need to be developed for small-scale

projects, as this is often the scale at which (volunteer) practitioners have the capacity to work.

2. Funding specifically for monitoring needs to be made available in association with restoration projects. This can be a portion of project funding that is allocated for monitoring, or a targeted funding stream specifically for monitoring once projects are approved and funded.
3. CBWM organizations should use a multivariable monitoring approach that utilizes chemical, physical, and biological water monitoring parameters. This monitoring should be conducted routinely at standardized locations throughout the watershed. For project specific monitoring, appropriate indicators should be chosen and assessed pre- and post-project.
4. CBWM organizations should periodically review and assess frequently used restoration techniques within their watershed. This review should periodically select one such project and conduct in-depth monitoring of physical, chemical, and biological monitoring parameters. This could aid in building understanding of how aquatic ecosystems respond to the restoration activity without the large financial commitment of conducting in-depth monitoring on all projects.

In light of the findings from my study, the following recommendations are suggestions for future research in this area.

1. In future studies that utilize photo-elicitation techniques for the evaluation of restoration-based research, my findings suggest that photographic protocols should be incorporated into CBWM projects from the start. Planning of the photo-elicitation activity should be coordinated with research participants to ensure clarity of the methodology and to incorporate any feedback into the process. This would ensure the development of a data rich project capable of documenting key aspects being targeted by the research. Researchers should be aware that a project such as this would entail a substantial time commitment requiring a large commitment from research participants, upon which the researcher would have to depend. As photo-elicitation is a visual medium, it is recommended that any



projects conducted on restoration-based research incorporate an adequate monitoring data collection phase to allow for data triangulation through measurement of ecosystem parameter improvements over time.

2. There is a need for monitoring to be conducted on restoration projects, and a project with the capacity to conduct monitoring could aid in filling the gap in scientific literature regarding the assessment of restoration techniques. This research could also aid in building understanding of restoration projects from a non-academic point of view as opposed to projects that are specifically designed and implemented by academics for investigator-driven purposes.
3. Many research studies focus on cases of ‘success’, but few focus on what would be perceived as ‘failure’. Research needs to be conducted with practitioners on cases of restoration that are classified as failures to identify the factors that prevent the implementation of successful restoration.
4. All of the CBWM groups that participated in my study had programs that focused on public education, and the extent of people that these programs reach and influence is largely unknown. Research on the value of these programs and how they contribute to environmental awareness and environmental stewardship opportunities could help CBWM organizations with developing and implementing such programs.

## **5.7 Conclusion**

My thesis was developed to identify and document activities conducted by CBWM organizations that contribute to observable and measurable benefits within aquatic ecosystems. To achieve this goal, I utilized an innovative methodological technique for assessing restoration projects where photographs were paired with in-depth interviews to obtain information on the planning, conducting, and follow-up to restoration projects. I was able to identify and document cases where restoration led to observable ecosystem improvements that were supported through photographic evidence and scientific literature. Cases where restoration led to measurable responses within aquatic ecosystems were rare; by this, I mean that the CBWM organization did not have the measures. Out of

15 projects only one project demonstrated measurable changes within the collected monitoring data that verified a positive ecosystem response to restoration. The disparity between projects with documented observable and measurable improvements identifies limitations in the monitoring procedures being implemented as well as the limited (financial, technical, human) capacity found within many CBWM organizations. This thesis identifies challenges within current monitoring practices, CBWM capacity, and scientific understanding of aquatic ecosystems and offers a number of recommendations on how to address them.

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## Appendix A: Dalhousie Research Ethics Board Approval



Social Sciences & Humanities Research Ethics Board  
Letter of Approval

July 23, 2013

Mr Chris Garda  
Management Resource & Environmental Studies

Dear Chris,

**REB#:** 2013-3059

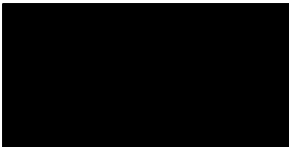
**Project Title:** "Assessing Aquatic Ecosystem Health: Does Community Based Monitoring Contribute to Benefits Within the Ecosystems it Monitors?"

**Effective Date:** July 23, 2013

**Expiry Date:** July 23, 2014

The Social Sciences & Humanities Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on *Ethical Conduct for Research Involving Humans*. This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Sincerely,



Dr. Sophie Jacques, Chair

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Post REB Approval: On-going Responsibilities of Researchers

# Appendix B: Saint Mary's University Research Ethics Board Approval



RESEARCH  
ETHICS BOARD

Department Office  
T 902.420.5728  
F 902.496.8772  
E ethics@smu.ca

## Certificate of Ethical Acceptability for Research Involving Humans

This is to certify that the Research Ethics Board has examined the research proposal:

<b>SMU REB File Number:</b>	14-007
<b>Title of Research Project:</b>	Assessing Aquatic Ecosystem Health: Does Community Based Monitoring Contribute to Benefits Within the Ecosystems it Monitors?
<b>Faculty, Department:</b>	Science, School for Resource and Environmental Studies
<b>Faculty Supervisor:</b>	Dr. Cathy Conrad
<b>Faculty Co-Supervisor:</b>	Dr. Heather Castleden (Dalhousie University)
<b>Student Investigator:</b>	Chris Garda

and concludes that in all respects the proposed project meets appropriate standards of ethical acceptability and is in accordance with the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans (TCPS 2) and Saint Mary's University relevant policies.

Approval Period: September 24, 2013 – September 24, 2014\*

### Post-approval Reporting Requirements

#### ADVERSE EVENT

Adverse Event Report: <http://www.smu.ca/academic/reb/forms.html>  
Adverse events must be immediately reported (no later than 1 business day).  
SMU REB Adverse Event Policy: <http://www.smu.ca/academic/reb/policies.html>

#### MODIFICATION

FORM 2: <http://www.smu.ca/academic/reb/forms.html>  
Research ethics approval must be requested and obtained prior to implementing any changes or additions to the initial submission, consent form/script or supporting documents.

#### YEARLY RENEWAL\*

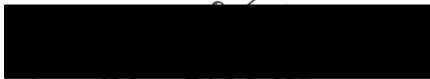
FORM 3: <http://www.smu.ca/academic/reb/forms.html>  
Research ethics approval is granted for **one year only**. If the research continues, researchers can request an extension one month before ethics approval expires.  
FORM 4: <http://www.smu.ca/academic/reb/forms.html>  
Research ethics approval for course projects is granted for **one year only**. If the course project is continuing, instructors can request an extension one month before ethics approval expires.

#### CLOSURE

FORM 5: <http://www.smu.ca/academic/reb/forms.html>  
The completion of the research must be reported and the master file for the research project will be closed.

\*Please note that if your research approval expires, no activity on the project is permitted until research ethics approval is renewed. Failure to hold a valid SMU REB Certificate of Ethical Acceptability or Continuation may result in the delay, suspension or loss of funding as required by the federal granting Councils.

On behalf of the Saint Mary's University Research Ethics Board, I wish you success in your research.



Dr. Jim Cameron, Ph.D.  
Chair, Research Ethics Board, Saint Mary's University

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## Appendix C: Informed Consent Form

### Informed Consent Form



#### **Research Project: “Assessing Aquatic Ecosystem Health: Does Community Based Monitoring Contribute to Benefits Within the Ecosystems it Monitors?”**

Please circle Yes or No, for the following:

1. Do you understand that you have been asked to take part in a research study?  
**Yes No**
2. Have you received and read the attached Information Sheet?  
**Yes No**
3. Do you understand the benefits and risks involved in taking part in this research study?  
**Yes No**
4. Have you had an opportunity to ask questions and discuss this study with Chris Garda?  
**Yes No**
5. Do you understand that you can withdraw from taking part in this study at any time up until the data has undergone preliminary data analysis  
**Yes No**  
\*You do not have to say why you have decided to withdraw.
6. Has the issue of confidentiality been explained to you?  
**Yes No**
7. Do you understand who will have access to the records from these discussions?  
**Yes No**
8. Do you consent to the photographs that you provided for this study to be used in publications? **Yes No**
9. Do you consent to being audio-recorded?  
**Yes No**
10. Do you consent to quotations from the interviews being used in the study?  
**Yes No**
11. Would you like your name to be included with quotations?  
**Yes No**
12. Would you like to review your transcript to check for accuracy?  
**Yes No**
13. Would you like to receive a copy of the preliminary analysis and your quotations included in the text for comment?  
**Yes No**
14. Would you like an electronic copy of the final report?  
**Yes No**

I agree to participate in this research project.

\_\_\_\_\_  
Printed Name of Research Participant

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature of Research Participant

\_\_\_\_\_  
Printed Name of Researcher

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature of Researcher

### Information Sheet

**Research Project:** *Assessing Aquatic Ecosystem Health: Does Community Based Monitoring Contribute to Benefits Within the Ecosystems it Monitors?*

#### Contact Information

##### Principal Investigator/Interviewer

Chris Garda  
School for Resource and Environmental Studies  
Dalhousie University  
Email: [cgarda@dal.ca](mailto:cgarda@dal.ca)  
Phone: (902) 449-9077

##### CURA H2O Principal Investigator

Dr. Cathy Conrad  
Department of Geography  
Saint Mary's University  
Email: [cconrad@smu.ca](mailto:cconrad@smu.ca)  
Phone: (902) 420-5737

##### CURA H2O Co-Investigator

Dr. Heather Castleden  
School for Resource and  
Environmental Studies  
Dalhousie University  
Email: [heather.castleden@dal.ca](mailto:heather.castleden@dal.ca)  
Phone: (902) 494-2966

This research project is being conducted by Chris Garda, a graduate student, as part of the Community University Research Alliance project titled "Community-Based Integrated Water Monitoring and Management in Nova Scotia (CURA H2O)". The project is jointly funded by the Social Sciences and Humanities Research Council (SSHRC) and the Water Economics, Governance and Policy Network (WEPGN) and has been reviewed by the Dalhousie University Social Sciences and Humanities Research Ethics Board. This document will outline your rights as a participant if you decide to take part in this study. Please read it carefully.

**Purpose:** This research seeks to identify and document activities conducted by community-based monitoring (CBM) organizations that have the potential to aid in the protection of or benefit the natural ecosystem. With the growing number of CBM organizations within Canada, there is still limited research on the linkages between CBM and its effect on the natural ecosystem. By working with CBM organizations this research aims to identify and document such linkages.

**Your participation:** Your organization was asked to suggest a single member to participate in (Phase 1) an interview session and (Phase 2) a 'participant-employed photography' interview that uses photographs taken by your organization to discuss projects conducted by community-based monitoring groups. The member selected was to be an individual who is actively involved in the planning, organization, and



implementation of activities conducted by your organization. Additionally, they were to have in depth knowledge of the past and present activities conducted by your organization. Based on these criteria, your organization identified you as an ideal candidate to participate in this research. Your participation is completely voluntary and you will not be penalized if you decide not to participate.

If you do agree to participate, In Phase 1, I will conduct an interview with you to gain a general understanding of your organization on topics such as why they monitor, what types of monitoring they conduct, and identify actions conducted by the CBM organization that have the potential to effect the ecosystem. The interview will take approximately 1 hour, and will be recorded using a digital audio recorder. The interview will be conducted by phone. The participant-employed photography (PEP) interview will be scheduled to take place following, but not on the same day as, the interview. Photographs selected by you or your organization will be used to facilitate discussion on some of the different project types that were identified during the interview. Your selection of photos for the PEP interview is estimated to take approximately 2 hours. Once you have selected the photos, we will schedule a second interview, this time face-to-face in your community, where we will focus on the contents of the pictures you selected to discuss the planning process leading up to the project, how the project was conducted, and the result of the project. This interview will take approximately 1.5 hours, and will be recorded. Additionally, water quality monitoring data will be requested when applicable (e.g., when data is related to one of the activities being discussed in the PEP interview). Total time commitment is estimated at 4.5 hours. The interview and PEP phases will be conducted on separate days, and will be scheduled within a timeframe that works best for each participant.

**How this research will be used:** Information collected from both interviews and the participant-employed photography activity will be transcribed and analyzed using computer software, and important quotations will be used in a final report, publications, and presentations with your permission. Your name will be kept confidential and will be given an anonymous identifier (e.g. pseudonym or fake name). You will have the opportunity to review the transcript of both interviews, to check for accuracy before they are analyzed. In addition, you will have the opportunity to view how quotes from your interviews may be used in any reports (thesis, publication, presentations to make clarifications or remove items).

**Benefits of this study:** This study may not directly benefit your organization. However, the information obtained from this research will aid in generating new knowledge regarding the benefit of community-based monitoring to the natural ecosystem. Additionally, the research may provide information on how CBM groups can best plan activities that will benefit the natural ecosystem.

**Risks:** The risks to you or your organization by participating in this research are minimal. Interviews will take place at a time and place that is comfortable to you. If you or your organization does feel at risk, you may withdraw from the study at any time up until the data have undergone preliminary data analysis, without consequence.

**Withdrawal from this study:** Participating in this study is completely voluntary. You may refuse to participate or later withdraw up until the data has undergone preliminary data analysis, without consequences to you or your organization. If you choose to withdraw, any data that you or your organization provided will not be kept by researcher and will be removed from the dataset. If you wish to withdraw, simply contact any of the researchers on the first page, using the contact information above.

**Confidentiality:** Every effort will be made to ensure that no identifying information of participants is made available beyond the graduate student (Chris Garda) and the project investigators (Dr. Heather Castleden and Dr. Cathy Conrad) and committee member Dr. Karen Beazley. However, given the small cohort of CBM groups that participants will be selected from, anonymity cannot be fully guaranteed. All data will be kept in a secured locked storage area at the School for Resource and Environmental Studies office at Dalhousie University during the course of the study. Electronic data will be kept on password-protected computers and only the research team will have access to this information. Identifying information will be stored in a separate location from the interview transcripts. The raw data will only be available to the graduate student (Chris Garda), the project investigators, and committee member. When the study is complete, data will be kept for five (5) years and then it will be destroyed.

**Consent:** A signed consent form is required to participate in this study. Prior to conducting the interviews and PEP activity, I will go over the information sheet and consent form with you and answer any questions that you may have. Signing the consent form indicates that you have agreed to participate in both Phase 1 and Phase 2 of the proposed research study.

Thank you,

Chris Garda,  
BASc, MES (candidate)

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*If you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, you may contact Catherine Connors, Director, Research Ethics, Dalhousie University at (902) 494-1462, [ethics@dal.ca](mailto:ethics@dal.ca).*

## Appendix E: Email Recruitment Script



<Date>

**To: <Organization>**

Hello,

My name is Chris Garda and I am a graduate student at the School for Resource and Environmental Studies at Dalhousie University, Halifax, Nova Scotia. I am currently conducting a research project on community-based water monitoring and the effect that it has on the natural ecosystems being monitored entitled, *Assess Aquatic Ecosystem Health: Does Community Based Monitoring Contribute to Benefits Within the Ecosystems it Monitors?* My research is being conducted as part of the larger CURA H2O (curah2o.com) research project, which your organization is already serving as a research partner. My research is being funded by the Social Sciences and Humanities Research Council of Canada and the Water Economics, Policy, and Governance Network. The purpose of my research project is to help generate knowledge regarding community-based monitoring (CBM) and the benefits it provides to the natural ecosystems being monitored.

I am inviting your CBM organization to identify one member to voluntarily participate in (1) an interview, and (2) an activity that uses photographs taken by your organization to discuss monitoring activities that you have conducted. The member should have solid working knowledge of the past and present activities conducted by your organization, and play an active role in the planning, organization, and implementation. Additionally, I would request permission to use your organization's monitoring data (e.g. water quality data, habitat assessment data). Participation by the individual representing your organization is completely voluntary and there are no right or wrong answers in this study. If this individual decides to participate they can also choose to withdraw at any time until the data has undergone preliminary data analysis, without consequence by informing me that they wish to withdraw.

To be eligible to participate in this research you must be a community-based water monitoring organization that is reliant on volunteers to conduct a majority of monitoring and project activities. Additionally, the organization should have and be able to provide records of past projects conducted (including photographs), and monitoring data for these projects if possible.

If you are interested in taking part in this research, please have the member who will participate in the research project contact me, and I will provide further information regarding the study. If you have any questions, please feel free to contact me using the contact information provided at the bottom of this letter.

Thank you, and I hope that you consider taking part in this study.

Regards,

Chris Garda  
School for Resource and Environmental Studies  
Dalhousie University  
Kenneth C. Rowe Management Building  
6100 University Avenue, Suite 5010  
Halifax NS B3H 4R2

Email: [cgarda@dal.ca](mailto:cgarda@dal.ca)

Telephone: 902-449-9077

## Appendix F: Telephone Recruitment Script

### Telephone Recruitment Script

*Three days after the recruitment email is sent, CBM groups that have not replied will be contacted by phone to see if they have received the email and ask if they would be interested in participating in the study. The CURA H2O research team will provide phone numbers and contact info of the person identified as an appropriate 'key informant'.*

Hello \_\_\_\_\_ (watershed group member):

My name is Chris Garda and I am a graduate student at Dalhousie University in Halifax. I am conducting a research project titled "*Assessing Aquatic Ecosystem Health: Does Community Based Monitoring Contribute to Benefits Within the Ecosystems it Monitors?*" I sent an email to your organization about three days ago to see if you would be interested in participating in this study. **1)** Did you receive the email and did you have an opportunity to have a look at it?

*If yes to question 1*

That's great. **2)** I was wondering if your organization might be interested in participating in the study? or Is there a more appropriate person for me to talk to regarding this? **3)** Before I continue, do you have any questions?

*If no to question 1*

Well I could tell you about the study now if you like. I am a researcher working as part of the CURA H2O project (*all participants will be CURA H2O partners so they will be familiar with the project*) to examine the relationship between CBM actions and how they may potentially benefit the ecosystem being monitored. What I am looking to do is identify actions conducted by CBM organizations, including, for example, habitat creation, riparian zone restoration, liming projects, and assess if these actions provide ecosystem benefit. I will be asking people to volunteer to participate in an interview and a 'participant-employed photography' session that uses photographs that were taken by your CBM organization to discuss actions that you have conducted. **2)** Would you be interested in participating in the study? **3)** Before I continue, do you have any questions?

*If yes to question 2*

That is great. Thank you.

I will send you an information package about the study and a consent form, but before we go much further, there are a few key criteria that I am using to determine watershed group eligibility to participate.

Does your organization collect and maintain records of monitoring data? Records might include things like water quality, fish population surveys, etc.?

Would you be able to provide photographs of activities that your organization has conducted? Photographs might include things like restoration projects, improvement projects.

*If they meet criteria*

Thank you very much for your time, I will send you the information package and consent form by email right away. Please don't hesitate to contact me if you have any questions or require additional information (*provide contact information if desired by participant*).

**3) Do you have any questions?**

*If they do not meet criteria*

Thank you very much for your time, unfortunately I require that data in order to conduct my research. Please feel free to contact me if you have any further questions, or if you find that you can provide that information and would still like to participate in the study (*provide contact information*). Have a good day.

*If no to question 2*

Ok, thank you for your time. If you change your mind, or have additional questions regarding this study please feel free to contact me (*provide contact info*). Have a good day.

*If yes to question 3 or at any point contact person has questions, questions will be answered to the best of my ability.*

## Appendix G: Phase 1 Interview Guide



### Interview Guide

#### Preamble

*Thank you very much for agreeing to participate in my research project on community-based monitoring (CBM), in order to better understand the potential benefits that it provides for the natural ecosystem.*

*As I said in the invitation, I will be recording our conversation. But before I turn on the recorder, I want to tell you a little bit about how our conversation will go. The interview will take about an hour and our conversation will be about your CBM organization. More specifically, I will be asking about your organization in general and then focusing on identifying activities that your organization conducts that have the potential to benefit the natural ecosystem that you are monitoring.*

*There are no right or wrong answers. If there are things you don't want to talk about that's ok. We'll just move on. If you say something that you don't want recorded, just say so, and it can be removed, even after we have completed the interview. The information provided in this interview will be kept confidential and the only people who will access this information are my project supervisors (Dr. Heather Castleden and Dr. Cathy Conrad) my research committee member Dr. Karen Beasley, and myself. All original notes, digital recordings and back-up files will be stored at Dalhousie University in a secure location and will be kept until 2018 at which point they will be destroyed.*

*I'd like to also remind you that your participation is completely voluntary, that you are free to withdraw now or any time until the preliminary data analysis is completed. If you do choose to withdraw, none of your information provided will be used. This research will be used to develop presentations and publications related to community-based water monitoring in the Maritime provinces, and for my master's thesis. In any of these documents or dissemination of the research, you will not be identified by name, and all quotations will be an anonymous identifier (e.g. pseudonym or fake name).*

*Do you have any questions before we get started?*

#### **Participant Introduction:**

First, I would like to hear a little bit about the organization you are a part of, and your role within the organization.

#### **I. Introductory:**

1. Can you tell me about the (name of organization)?
  - a. What was the reason for it being established?
  - b. Could you tell me about any goals that you are trying to achieve?  
(prompt: water quality improvement, species protection)
  
2. How did you become involved with the (name of organization)?
  - a. How has your role changed over time?

## **II. Exploratory:**

1. Could you tell me about some of the environmental problems you encounter?  
(prompt: water quality, decrease in aquatic life populations)
  - a. How would you be able to assess these?
  - b. Is there any information available to aid you with this?
3. What types of activities does your organization conduct to prevent or mitigate any of the problems identified?
  - a. Are any of these activities triggered due to monitoring?
7. Who is involved in the planning process for these activities?  
(prompt: academics, regulatory agencies?)
8. From the types of projects that we discussed in this interview do any specific projects come to mind that would be good to discuss in depth for Phase 2, the participant-employed photography, part of this study?

## **III. Participant driven:**

*Thank you very much for talking with me. I don't think there is anything left for me to ask you about, but I wonder if there might be something that you wanted to say that I haven't asked you?*

*Okay, thank you. I just wanted to re-emphasize that everything you've shared today will remain confidential and a fake name will be used for any of the quotes I take from this interview in any publications or presentations that I produce. If you have any questions or concerns regarding today's interview, please do not hesitate to contact me, or my academic supervisor, or the Dalhousie research ethics office.*

*If participant has indicated he/she would like to see transcript to check for accuracy:*

*In the next few weeks, I will be transcribing our conversation and I see from your consent form that you would like to review the transcript. I will send that to you by email and give you about a week to review it. If I don't hear from you by then, I'll assume that you are satisfied with it and don't see any need for changes.*

*OR*

*If the participant has indicated that he/she would not like to see transcript to check for accuracy:*

*In the next few weeks, I will be transcribing our conversation and I see from your consent form that you did not want to review the transcript; I thought I would just mention it again in case you have changed your mind... if yes, see above, if no, then:*

*If the participant has indicated they wanted to review how quotes would be used in text for thesis/publications say:*



*Also, once I have completed my data analysis I will provide you with a copy of how your quotes will be used in my thesis/publications so that you may check that I am not misrepresenting you comments.*

Thanks so much, it was great to talk with you. [END].

## Appendix H: Phase 2 PEP Information Sheet



### PEP Information Sheet

#### *Assessing Aquatic Ecosystem Health: Does Community Based Monitoring Contribute to Benefits Within the Ecosystems it Monitors?*

Thank you very much for completing the interview phase of my research study on community-based monitoring (CBM), in order to better understand the potential benefits that it provides for the natural ecosystem. It was great to have the opportunity to talk with you, and to learn about your organization's activities.

In preparation for the next phase (2) of my research, I would like to explain the participant-employed photography (PEP) activity, which will aid you in the selection of your organization's existing photographs to be used during the activity. PEP uses photographs taken by individuals, or in your case, organizations, to facilitate conversation about the topic being discussed. It is an opportunity for you to showcase something that is meaningful to your organization and aid in explaining the activities conducted. For my research, I am asking you to select photographs of activities conducted by your organization that have the potential to benefit the ecosystem that you are monitoring. Some of the activities that you identified during the interview were: (I will add activities identified during the interview here). These are just suggestions, as there may be other activities for which you have photographs that were not discussed during the interview. Please select photographs of three to five activities that your organization has conducted. I am estimating that the selection of and obtaining photos for the PEP activity will be approximately 2 hours. To aid in the selection here are a few suggestions:

- You should be knowledgeable about the activities that you select;
- Photographs should portray the different stages of the activity (before, during and after);
- The location of the activity and dates that was activities were conducted should be known;
- Activities that have associated monitoring data (e.g. habitat restoration, bank stabilization, installation of in-stream structures (digger logs), sediment prevention) that can show the cause and effect of the activity are ideal but not required.

If you have any questions or require assistance please feel free to contact me. I will give you about two weeks to select your photographs and will contact you on (X date) to schedule and appointment to meet you to discuss the activities in our second (and last) interview. I look forward to meeting with you.

Sincerely,  
Chris Garda

### Contact

Chris Garda  
School for Resource and Environmental Studies  
Dalhousie University  
Email: [cgarda@dal.ca](mailto:cgarda@dal.ca)  
Phone: (902) 449-9077

## Appendix I: Phase 2 Interview Guide



### Participant-Employed Photography Guide

#### Preamble

*Thank you very much for agreeing to participate in my study on community-based monitoring (CBM), in order to better understand the potential benefits that it provides for the natural ecosystem.*

*As I said in the information letter, I will be asking you about the activities that were identified in the interview that have the potential to benefit the natural ecosystem you are monitoring. Before I turn on the recorder, I want to tell you a little bit about how our conversation will go. The participant-employed photography activity will take about 2.0 hours and our conversation will focus on activities that your CBM organization has conducted. More specifically, I will be using the photographs that you have provided to facilitate an in-depth conversation about each of the activities. We will go through the activities one at a time and focus on the planning, conducting and follow up phases of each activity.*

*I just wanted to remind you that during the interview I will be using a digital audio recorder to record our conversation. There are no right or wrong answers. If there are things you don't want to talk about that's ok. We'll just move on. If you say something that you don't want recorded, just say so, and it can be removed, even after we have completed the interview. The information provided during this activity will be kept confidential and the only people who will access this information are my project supervisors (Dr. Heather Castleden and Dr. Cathy Conrad) my committee member Dr. Karen Beazley and myself. All original notes, digital recordings and back-up files will be stored at Dalhousie University in a secure location and will be kept until 2018, at which point they will be destroyed.*

*I'd like to also remind you that your participation is completely voluntary, that you are free to withdraw now or any time until the preliminary data analysis is completed. If you do choose to withdraw, none of your information provided will be used. This research will be used to develop presentations and publications related to community-based water monitoring in the Maritime provinces, and for my master's thesis. In any of these documents or dissemination of the research, you will not be identified by name, and all quotations will be an anonymous identifier (e.g. pseudonym or fake name).*

*Do you have any questions before we get started?*

*(Questions numbered 1-4 will be asked directly to the interviewee. Questions with a check box in front of them indicate information required for the research, but will only be asked if the interviewee does not address these factors in their response.)*

*Ok, I'm excited to see your pictures and hear about your activities so let's get started.*

## **I. General:**

1. What type of project/activity are we looking at?

- Where and when was it conducted? (How often for repeat activities)
- What triggered the need to conduct the project (reason it was conducted)?
- Is this something that is a concern throughout the watershed?

## **II. Planning the Activity**

2. Would you be able to tell me about the planning process leading up to conducting this activity?

- What was the planning process for this activity?
  - Who was involved in the planning process?
  - Was any monitoring data used in the planning process?
  - Were any approvals from regulatory agencies or other sources required?

## **II. Conducting the Activity**

3. Could you explain to me how this activity was conducted? (using photographs when possible)

## **III. Follow-up to the Activity**

4. Could you tell me about any project follow-up that was conducted?

- Was the intended outcome of the activity achieved? (was it successful)
  - Were there any observable improvements to the ecosystem?
- Were there any measureable improvements to the ecosystem?
- Was any follow-up maintenance required?

5. What do you see in the pictures, what is working as intended and what isn't?

6. Do you think that this activity was successful in providing a benefit to the ecosystem, what benefit? Was it a success amongst failures of similar types of activities?

## **IV. Participant Driven**

*Thank you very much for talking with me. I don't think there is anything left for me to ask you about, but I wonder if there might be something that you wanted to say that I haven't asked you?*

*Okay, thank you. I just wanted to re-emphasize that everything you've shared today will remain confidential and a anonymous identifier will be used for any of the quotes I take from this interview in any publications or presentations that I produce, unless you have stated otherwise on the consent form. If you have any questions or concerns regarding today's interview, please do not hesitate to contact me, or my academic supervisor, or the*

*Dalhousie research ethics office.*

*If participant has indicated he/she would like to see transcript to check for accuracy:*

*In the next few weeks, I will be transcribing our conversation and I see from your consent form that you would like to review the transcript. I will send that to you by email and give you about a week to review it. If I don't hear from you by then, I'll assume that you are satisfied with it and don't see any need for changes.*

*OR*

*If the participant has indicated that he/she would not like to see transcript to check for accuracy:*

*In the next few weeks, I will be transcribing our conversation and I see from your consent form that you did not want to review the transcript; I thought I would just mention it again in case you have changed your mind... if yes, see above, if no, then:*

*Also, once I have completed my data analysis I will provide you with a copy of how your quotes will be used in my thesis/publications, along with the pictures that accompany them so that you may check that I am not misrepresenting you comments. Any picture used in this research for publications, presentations, and my thesis report that have people displayed in them will require signed consent from the person(s) to use their likeness. The following form (show: Appendix H: Photo Release Form) will need to be approved by them prior to the photographs being used. Would you be able to provide these volunteers with the form and my contact information?*

Thanks so much, it was great to talk with you. [END].