

ADAPTIVE MANAGEMENT STRATEGIES ON THE CHESAPEAKE BAY
REGARDING TMDLS

by

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ABSTRACT

In December 2010, the United States (U.S.) Environmental Protection Agency (EPA) released a cleanup plan for the Chesapeake Bay known as the Total Maximum Daily Load (Bay TMDL). The Bay TMDL document established nutrient and sediment allocations with the goal of having practices and controls in place for an expected

60 percent reduction of the nutrient and sediment pollution loads by 2017, with all practices and controls installed by 2025 to meet water quality standards in the Bay. The seven Bay watershed jurisdictions¹ within the watershed developed Watershed Implementation Plans (WIPs) to meet the nutrient and sediment allocations. Though considerable resources have been committed to the implementation of the Bay TMDL, there is growing concern that the Bay TMDL is not resulting in improved attainment of water quality standards in the Bay.

This study will disseminate research results evaluating and assessing adaptive management strategies for the Bay TMDL based on the effectiveness of existing water quality initiatives. Adaptive management strategies and practices are essential to addressing those uncertainties posed by the inefficiencies of current Bay water quality strategies.

¹ Delaware, Maryland, New York, Pennsylvania, West Virginia, Virginia, and the District of Columbia

Methods employed are (1) semi-structured interviews of federal and state government staff members involved in the implementation of the Bay TMDL and of stakeholders, including NGOs and farmers, who can shed light on the efficacy, successes, constraints and prioritization of adaptive management strategies in the context of the Bay TMDL and (2) water quality data analysis. TMDL plan performance and programs are then measured using program evaluation tools. This approach facilitates the assessment of different resource sustainability and restoration programs as well as defined priorities and objectives.

This research will provide information and insight into the decision-making process as well as highlight the possible reasons behind any ineffectiveness of the TMDL. The Chesapeake Bay may benefit from the application of suggested adaptive management strategies, which include integrative, flexible and responsive management policies.

Chapter 1

INTRODUCTION

The Chesapeake Bay is the largest estuary in the United States with over 64,000 square miles in the watershed (Environmental Protection Agency, 2015). There are many factors that influence the health of the Chesapeake Bay including agriculture, air pollution, population growth and regulation. In particular, pollutants and nutrients have been a topic of concern because they include pharmaceuticals, pesticides, and metals which harm both human and wildlife health. There are four general sources of Chesapeake Bay pollutants: agriculture runoff, storm water runoff, air pollution, and wastewater (Chesapeake Bay Program). Algae in the Bay are being fertilized by the excess nutrients, which stimulate the algae's growth, diminish water quality, and deplete oxygen levels once the algae die and decompose (Chesapeake Bay Program). Additionally, the water quality in tributaries remains low. The three main pollutants that degrade water quality in the Chesapeake Bay are nitrogen, phosphorus, and sediment (Boynton, 2000). According to Claudia Copeland, author of the Congressional Research Service's Clean Water Act and Pollutant Total Maximum Daily Loads (TMDLs), the result on Bay health is polluted water, reduced populations of fish and shellfish, and degraded habitats (Boynton, 2000; Copeland, 2012).

The Clean Water Act (CWA) requires that states identify a total maximum daily load (TMDL) for each pollutant – the combined amount of pollution from point that a waterbody can receive while meeting water quality standards (WQS's). Point sources are released from discrete, single discharges. Single point sources include

pipes, factories, sewage treatment plants, or industrial wastewater discharges (Aiken, 2017). Point source discharges are required to be treated through the National Pollution Discharge Elimination System (NPDES) permitting program. However, nonpoint sources are not regulated under the CWA, but they can be regulated by states if they choose (Aiken, 2017). Nonpoint source pollution is a combination of pollutants from large areas rather than specific sources. Contributors of nonpoint pollution include agriculture runoff, stormwater, and atmospheric deposition.

In response to previous failed efforts to clean up the Chesapeake watershed, the six Bay states and the District of Columbia requested that the U.S. Environmental Protection Agency (EPA) a) are required to allocate point sources, and b) agreed to create a Bay-wide Total Maximum Daily Load (TDML) to limit the runoff amount of nitrogen, phosphorus and sediment entering the Bay (Jones, 2014). Individual states of the Bay watershed have identified the TMDL sources from which the nutrient flows originate, including agriculture, sewage treatment plants, storm water runoff, and septic tanks. Under the Clean Water Act (CWA), Section 303(d) requires states to identify waters that are impaired by pollution, even after functioning pollution controls are implemented (Clean Water Act of 1972, 33 U.S. Code § 1313). Section 303 requires that states establish surrounding ambient water quality standards for water bodies, including those of recreational, public, water supply, or industrial water supply (Clean Water Act of 1972, 33 U.S. Code § 1313). These standards are used to determine which waters must be subject to cleanup efforts. In addition, Section 303 standards determine how much effluent may be discharged and what is needed for protection (Copeland, 2012). However, also under the CWA, states are required to

identify point sources, but may choose to identify nonpoint sources to improve pollution in water quality.

This research will provide information and insight into Chesapeake Bay decision-making process as well as highlight the possible reasons behind any ineffectiveness of the TMDL.

The Plan for Cleanup: TMDL

In December 2010, the U.S. EPA released the TMDL for the Chesapeake Bay (Bay TMDL) (Chesapeake Bay Executive Summary, 2010; Jones, 2014). The Bay TMDL set provisional nutrient limits for the years 2017 and 2025, with 2025 being the final accountability year. Jurisdictions residing on the Chesapeake Bay were to develop the Bay TMDL in order to meet nutrient limits that EPA identified for each state: Delaware, Maryland, New York Pennsylvania, Virginia, and the District of Columbia. More specifically, the Bay TMDL set pollution reduction limits of 185.9 million pounds of nitrogen, 12.5 million pounds of phosphorus, and 6.45 billion pounds of sediment per year. From the base year of 2010, the 2017 limits were nitrogen load reductions of 15%, phosphorus 14%, and sediment 12% (Environmental Protection Agency, Bay TMDL, 2014). The 2025 limits were based on reductions from 2010 of 25% for nitrogen, 24% percent for phosphorus, and 20% for sediments. These pollution limits were further divided by Chesapeake Bay jurisdiction and major river basin. However, according to Nelson (2014, p. 330) if the states “do not undertake the actions necessary to realize these targets, as EPA interprets its TMDL responsibilities and authority, the state and local implementing jurisdictions would technically be ignoring their legal requirements.” The EPA is required to review and approve a state’s list of impaired waters and develop TMDLs where and when most

needed. Additionally, the CWA requires that the EPA create a list of impaired waters for the state and that the state makes its decision about TMDLs upon this review (Clean Water Act of 1972, 33 U.S. Code § 1313).

The Chesapeake Bay Program, under the auspices of the EPA, oversees the Chesapeake Bay watershed and is charged with implementing this plan. The EPA, Maryland, Pennsylvania, Virginia, and Washington, D.C signed the Chesapeake Bay agreement in 1983. The 1983 agreement suggested a major regional effort to restore and improve water quality in the Chesapeake Bay watershed (Chesapeake Bay Program, 1983). This agreement also created the Chesapeake Executive Council and the Chesapeake Bay Program office in Annapolis, Maryland – a partnership between a variety of government and nonprofit organizations in response to former U.S. senator from Maryland, Charles Mathias (Chesapeake Bay Program History). He led a grassroots movement to restore the Bay and obtained federal funding that would identify nutrient pollution, such as that from agricultural sources, as a primary pollutant (Houck, 2014). The intention was to solicit the help of governmental agencies, non-profit environmental organizations and local and state constituencies such as academic institutions and community advocacy groups. The Chesapeake Bay Program is coordinated by the federal government through the EPA, with the goal of leading and directing the Bay restoration and protection.

Membership includes the EPA administrator; the governors of Maryland, Pennsylvania and Virginia; the mayor of the District of Columbia; and the chair of the Chesapeake Bay Commission, which is a legislative body serving Maryland, Pennsylvania, and Virginia (Chesapeake Bay Program History). The governors of Delaware, New York and West Virginia have also committed to the water quality

goals of the Chesapeake Bay program. A second agreement was signed in 1987, which set a goal of 40% reduction in nitrogen and phosphorus by the year 2000 (Chesapeake Bay Program, 1987). In 2014, all six states in the Bay watershed signed another agreement on the Chesapeake Bay. The 2014 agreement contains ten goals, ranging from air quality to water quality attainment, while also reiterating the Bay states' goals for TMDL implementation and 100% of reduction strategies by year 2025 ("Chesapeake Bay Agreement"). Lastly, the agreement calls for stakeholder input through a series of management strategies (Chesapeake Bay Program, 2014). Further, states are responsible for implementing management strategies to achieve TMDL goals.² In particular, states are suggested to use the Chesapeake Bay Program's Accountability Framework.

States within the Chesapeake Bay watershed have agreed to restore to and maintain federal standards for watersheds that contribute nutrients and sediments to the Bay (Chesapeake Bay Program, 2014). The Accountability Framework includes rigorous measures to help ensure that cleanup commitments are met as well as short-term and long-term benchmarks, tracking and accountability for the jurisdictional activities, and federal contingency actions that can be employed if necessary in order to further develop the plan.

There are a number of nongovernmental organizations that have interests in the Bay, including the Chesapeake Bay Foundation, a nonprofit organization, which was established in 1967 after Maryland Congressman Roger C.B. Morton sought to restore

² Environmental Protection Agency. Section 10 Implementation & adaptive management. https://www.epa.gov/sites/production/files/2014-12/documents/cbay_final_tmdl_section_10_final_0.pdf

and maintain the waters of the Bay. Its essential mission is to maintain water quality for communities, the Bay system and its wildlife.

Watersheds and waterbodies are complex and dynamic systems. Consequently, understanding their mechanisms and identifying the many variables that impact their systems is problematic (Nyberg, 1999). According to Reckhow et al. (2011), the Chesapeake Bay Program has struggled to deal with ecological uncertainties in the Chesapeake Bay watershed. As a way to deal with these issues, C.S. Holling (1978) developed the concept known as adaptive management. Section 10 of the Bay TMDL requires that adaptive management be used to meet the nutrient and sediment reductions as a part of the Chesapeake Bay TMDL (Chesapeake Bay TMDL, Section 10).

An important goal of the Bay program specified within a WIP is the regulation of point sources and nonpoint sources of nutrients that must be evaluated separately in accordance with their contributions to water quality impairment of the Bay waters. State regulators overseeing the Bay watershed assign TMDL nutrient goals to the individual flow sources including agriculture, sewage treatment plants, storm water runoff, and septic tanks. These factors contribute to the need to understand the policy initiatives behind improving water quality within Bay watersheds.

Adaptitve Management

In 1999, Brian Nyberg proposed a way to gain better understanding of changing ecosystems. In particular, while studying forest ecosystems, Nyberg (1999) found that adaptive management allows forest managers to proceed responsibly when dealing with uncertainty by improving and refining policies. It is a rigorous way to learn from outcomes and adjust methods in order to accommodate for necessary

changes. This technique has been used for many ecological problems including the Columbia River Basin, management of acid rain, and management in the Florida Everglades (Nyberg, 1999) and has become an important component of ecological management.

In fact, the changes in land use, social values, and ecosystem knowledge have created many gaps, leading to uncertainty over how to best manage watersheds and waterbodies (Nyberg, 1999). Adaptive management is a way to address uncertainty, facilitating an open perspective for decision making among water managers, while lessening the social, ecological, and economic impacts that come with uncertainty (Nyberg, 1999). Uncertainty related to ecological causes and effects is a fact of life, however. Predicting the impacts on an environmental system is fraught with confounding variables. Thus, over time, the scientific management of ecological systems has employed adaptive experiments in order to foster an understanding of the systems.

Because of the way adaptive management was initially presented (Holling, 1978), it is a very complex concept that does not have a consistent definition in literature. Gregory et al. (2006) states that adaptive management consists of improving managers' knowledge with a set of well-defined goals and objectives through "implementation of carefully designed, quasi-experimental management interventions and monitoring programs." Adaptive management "reflects the understanding that many ecosystem management decisions must be made under uncertainty" (NAS, 2011). Adaptive management is clearly experimental, iterative, and has been offered as an effective strategy for reducing uncertainties (ibid). To Halbert (1993), "adaptive management is an innovative technique that uses scientific

information to help formulate management strategies in order to learn from programs that subsequent improvements can be made in formulating both successful policy and improved management problems.” Finally, Lyons (2008) and Doremus (2010), more recently suggest a working definition that includes a way to address uncertainty by facilitating an open perspective for decision-making among managers.

There are several attributes of successful adaptive management to be successful, including monitoring, data collection, costs and benefits, accommodation to spatial & temporal scales, community involvement, engagement facilitation, and accountability (Aceves-Bueno et al., 2015).

1. Monitoring – monitoring over time, which is integral to learning, must be incorporated in decisions in order to address uncertainty. Ineffective monitoring leads to failures in resource management.
2. Data collection – It is critical that scientists and researchers collecting data understand the explicit objective behind its collection; management objectives of data collection must be addressed for successful adaptive decisions. Monitoring data must also be quantitative and well defined.
3. Cost and Benefits – The costs of monitoring must be accounted for when implementing adaptive management; the monitoring costs must not outweigh the benefits during implementation of adaptive management. In particular, these costs can be either direct costs of data collection and analysis, or opportunity costs of using a resource as an experiment.
4. Accommodation to scales – Temporal and spatial scales must be considered because adaptive management decisions and outcomes are dependent on the costs, stakeholder buy-in, timeframe of monitoring, etc.
5. Community involvement – Those who are directly affected by decision-making play are integral to the implementation of adaptive management. Diversity of stakeholders enables deeper understanding and knowledge to inform natural resource management.
6. Stakeholder facilitation – Encouragement and support in addition to involvement is necessary for successful adaptive management. Fostering an effective relationship between managers and stakeholders improves success

of resource management initiatives. This is measured through forums or meetings with stakeholders to gain their inputs and perceptions. This allows managers to understand stakeholders, as well as for stakeholders to feel represented and gain new knowledge.

7. **Accountability** – The more stakeholders are involved in the decision-making process, the more collaboration is encouraged. However, managers and scientists must not lose sight of the objectives while ensuring the responsible involvement of stakeholders. For instance, the more stakeholders steer the decision-making, the more accountability may lead to flawed learning and decisions. A stable balance between stakeholder input and accountability must be equipped during this process.

Many authors and researchers have considered examples where uncertainty can manifest in resource management. Gilmour et al. (1999) analyzed three case studies on adaptive management related to urban water issues. The studies increased stakeholders' knowledge and understanding of management. Schindler and Cheek (1999) gained understanding of public involvement in decision making on resource management. They found that public involvement is crucial to processes such as adaptive management. Further, they found that successful and effective decision-making is a result of creating, disseminating, and evaluating knowledge of stakeholders for generating and implementing policies. Lastly, several authors (Holling, 1978; Walters, 1986; Van Wrinkle et al., 1997) contend “adaptive management should begin a concerted effort to integrate existing interdisciplinary experience and scientific information into dynamic models that attempt to make predictions about the impacts of alternative policies (Walters, 1997).” Notably, adaptive management is an iterative process that allows stakeholders to assess uncertainty about the environment, while incorporating social-ecological implications.

Holling (1978) incorporated the idea of adaptive management into economic, social, and environmental understanding in order to deal with uncertainty. He noted that environmental metrics should be presented at the beginning of the policy design

and development process and “should be integrated as equal partners with the economic and social dimensions” (Holling, 1978). It is crucial that management strategies are vigorous enough to deal with future challenges, while maintaining an understanding of changes in the ecosystem. In fact several authors (Holling, 1978; Walters, 1986; Van Wrinkle et al., 1997; Lyons et al., 2008), suggest modeling steps to integrate a “learning by doing” approach – which is also embedded in the previous criterion ‘monitoring’ (Aceves-Bueno et al., 2015):

1. The first step involves three different functions: a) clarifying the problem statement and involving key constituents, such as stakeholders, managers, and communicators; b) policy analysis in order to eliminate faulty alternatives that will not have a significant impact; and c) identifying key knowledge gaps that make model predictions unlikely to occur. Typically, these knowledge gaps include past relationships that have challenged traditional methods of scientific investigation.
2. The second step includes designing a “management plan and monitoring program that are informative and provide reliable feedback” (Nyberg, 1999).
3. The third step includes implementing the management plan. Oftentimes, deviating from the initial plan is useful when the underlying objectives are unclear and key constituents are biased to the decisions.
4. Monitoring is crucial to adaptive management as it allows programs to assess how actions affect indicators. This step is essential in assessing the effectiveness of an implemented policy or event, and it creates validity of model parameters and relationships.
5. In the fifth step, data are analyzed and compared to predictions made in the first step.
6. Lastly, management actions are adjusted or models updated according to the information and values used in the previous five steps. The objectives will be reviewed and adjusted in order to remain consistent with the outcomes or goals.

In addition to following these criteria, more recent studies are revealing a deeper underlying meaning behind adaptive management. Embedded in the above criteria is the ability for water managers to be considerate of a) resilience thinking, b) environmental governance, and c) adaptive governance (Cosens et al., 2018).

Resilience thinking is often used as a way to confront complex problems while observing behaviors that are consistent with the problems. It is often thought as a regime shift and how socio-ecological groups may adapt to changes. Adaptive management is coupled with resilience thinking as a way to remain neutral in the face of different perspectives: acting on the property that society values and property that society does not value. Thus, resilience thinking allows water managers to acknowledge viewpoints in the face of environmental change; it allows managers to confront societal changes, while linking those changes to both the social and ecological system.

Environmental governance addresses how societal goals are chosen in the face of environmental changes; how society interacts with those environmental changes; and how action is taken to make decisions (Rogers & Hall, 2003). It is critical that environmental governance is used as a mechanism within adaptive management because it considers the relationship between government and society: private actors, markets, and interest-based networks (Rogers & Hall, 2003).

Lastly, adaptive governance is essentially environmental governance coupled with the ability to adapt to changes. Adaptive governance must be performed by those working in governmental management and those enforcing environmental measures (Cosens et al., 2018). As proposed by Cosens et al (2018), adaptive governance must be capable of combining informal and formal networks in response to environmental

change, must have the ability to learn, and must be willing to evolve. For instance, attention to the process and procedure of adaptive management must be accounted for – this includes participation. However, substantive standards should be used in combination with participation, as it creates legitimacy and fairness, which in turn provides fundamental levels of psychological, social, and economic stability for communities to successfully adapt. Standards may influence the capacity of various networks, resource users and other interests (Cosens et al., 2018).

Adaptive Management in the Chesapeake Bay

Cosens et al (2018) note that competing interests, jurisdictional diversity, and multiple drivers of change characterize the management of large river basins. As such, they require many legal aspects of governance to play a role in implementation. Indeed, it is extremely difficult for managers of large river basins to maintain a consistent single management approach. There is a greater need for accountability in the way adaptive management is implemented, and adaptive management has the ability to resolve complex water issues as long as managers are able to address complexity, uncertainty, a regime threshold, and continuous identification of approaching thresholds (Cosens et al., 2018).

There are challenges to using adaptive management, including that it is difficult to understand how the adaptive management approach works (Halbert, 1993). The National Academy of Sciences (2011) observed that the Bay TMDL plan and the Watershed Implementation Plans (WIPs) incorporated into the plan suggest a lack of clear understanding of adaptive management. In order to meet requirements of adaptive management, the National Academy of Sciences (2011) suggested that the Bay and its jurisdictions fully analyze uncertainties relevant to decision-making, and

monitor any efforts by states within the watershed to ensure full support from the federal level. Scanlan (2013) noted that within Section 10 of the TMDL Executive Order (Implementation and Adaptive Management), the EPA does not mandate the use of the adaptive management approach for the Chesapeake Bay. In fact, the only mention of adaptive management within this section is “to take an adaptive management approach to the Bay TMDL and incorporate new scientific understanding of the effects of climate change into the Bay TMDL, in this case during the mid-course assessment (US EPA, 2010).” Scanlan (2013) further noted the lack of details on how this will be implemented. Adaptive management is an iterative process (Holling, 1978); however, Section 10 of the TMDL Executive Order fails to mention this.

In 2015, Richard Friesner at George Mason University conducted a study where perceptions and knowledge of local watershed managers of the Chesapeake Bay were evaluated concerning adaptive management. Only Maryland and Virginia were chosen for this study – the Patuxent, Potomac, and Rappahannock watersheds – and through an extensive amount of interviewing and surveying, Friesner observed that both Maryland and Virginia watersheds on the Chesapeake Bay had room to improve local understanding of adaptive management, as well as other implementation strategies for the Bay TMDL through adaptive management. In particular, survey data shows that local managers in the Rappahannock watershed need additional resources, such a funding or additional staff time. Additionally, it was found that local managers need more guidance and support from state and federal agencies. In particular, Friesner (2015) found that non-tidal portions of the Bay watershed require special attention.

There is large variation in state implementation strategies. Friesner (2015) noted this as a problem between Maryland and Virginia, resulting in lack of attention to implementation of the TMDL from Virginia. For instance, Maryland is better positioned to implement policies regarding the TMDL because it has a greater connection with the Bay itself. Perhaps as a result, Maryland began to focus of the Bay as early as 1744, with the development of its towns and shores. Finally, Maryland communicates implementation strategies directly to counties; whereas Virginia uses planning district commissions to disseminate information to localities (Friesner, 2015).

Next, Friesner (2015) found clear evidence of vast differences in understanding adaptive management among localities (Patuxent, Potomac, and Rappahannock watersheds). In particular, it was found that Maryland has a better understanding of adaptive management than that of Virginia. Friesner (2015) found that local managers are not involved or engaged in a way that is constructive in initial discussions with state and regional managers. Ultimately, private, state, and federal organizations and agencies must step up to provide targeted monitoring activities; otherwise, adaptive management at the local level cannot be accomplished (Friesner, 2015).

Discerning a consensus on the specific action elements of adaptive management also is a challenge. The examples noted here suggest a failure to meet adaptive management conceptualizations. The EPA uses Walters (1986), “learning by doing” approach; the CBP employs a “science-based” concept to redirect efforts based on previous outcomes, such as that from Halbert (1993). Because there is a lack of one usable, clear definition, it is necessary that watershed managers on the Chesapeake Bay have one, clear working definition of adaptive management.

Problem Statement

Considerable resources have been committed to implementing the Bay TMDL, including the use of WIP processes at the state and local levels. For instance, the Chesapeake Bay Program partners created what is known as the ‘Accountability Framework’ – a management strategy for the Chesapeake Bay, where the WIPs, two-year milestones, and mid-point assessments are spelled out and expected to be achieved by each partner and jurisdiction within the Bay watershed. They also agreed to a two-year milestone as part of the Bay TMDL’s accountability framework to assess progress towards achieving the 2025 water quality goals. Although this approach is consistent with those that are used to understand the trial and error process of adaptation and the capacity of jurisdictions to adapt (NAS, 2011), and it requires a particular assessment of uncertainties relevant to decision making, “Bay jurisdictions have not fully analyzed uncertainties inherent in nutrient and sediment reduction efforts and water quality outcomes (NAS, 2011).” Thus, there is growing concern that implementation efforts may not be sufficient to significantly improve water quality in the Bay.

In contrast to Friesner’s (2015) study on understanding how local managers in specific watersheds use adaptive management to implement the Chesapeake Bay TMDL, the present study focuses on a broader understanding adaptive management implementation of the Bay TMDL, attempting to understand the extent to which involved managers and stakeholders – at all levels of implementation – apply the adaptive management approach to the Bay as a whole. Further, perceptions and knowledge of key constituents are measured in order to understand the efficacy of TMDL implementation and the practicality of adaptive management as a method of the TMDL implementation. Semi-structured interviews of water quality managers and

other stakeholders at the state level shed light on whether uncertainty is existent, how it manifests itself, and on the effectiveness of the Bay TMDL. The study focuses on Maryland and Pennsylvania, as Maryland leads in water quality achievements while Pennsylvania is the largest contributor of Bay inflows to the Chesapeake.

Program Evaluation

Program evaluation is a process-based concept, focusing on how well activities are being performed (Wholey et al. 2010). In a program evaluation, attention is given to which decisions are made. Both Hatry (2006) and Wholey et al. (2010) presented guidance for designing and implementing studies of program processes and program outcomes. These methods include exploratory evaluation and performance measurement.

There are different methods used to analyze and evaluate the objectives and mechanics underlying programs and policies. First, policy-scientific methods focus on interviews, documents and argumentation analysis (Leeuw, 2003). Review of relevant scientific research can uncover the underlying assumptions, which can be tested through interviews of program constituents and staff members. It allows for further development of “discussion of expressing and assessing program theory (Leeuw, 2003).” In short, this method is based on how a program is supposed to work.

As discussed by Wholey (2006), the policy-science approach provides insight into a program’s objectives, priorities and effectiveness. It also facilitates understanding of the motives behind a program that addresses social, organizational, and policy problems (Leeuw, 2003). One of the strengths of this approach is its focus on documents and interview data. This type of analysis ensures validity of the underlying objectives of why and how a program works. A disadvantage of this

method is its “lack of attention paid to differences in power positions of the stakeholders (Leeuw, 2003, p. 9).” Stakeholders can have conflicting and overlapping political, economic and social interests.

The second method described by Leeuw (2003) is strategic assessment, which focuses on dialogue and open discussions. The goal of this method is to draw out underlying assumptions and perceptions about how a program works. These assumptions may be open for consideration among constituents and stakeholders. One of the strengths of this approach is the focus on group formation and group dynamics (Leeuw 2003). Sharing knowledge as well as perspectives is critical when attempting reconstruction of an existing initiative that has faced conflict. A weakness of this approach is that “too little attention is paid to differences in the power positions of the participants and the consequences for their group behavior (Leeuw, 2003, p. 13).” Comparing one group to another is crucial in decision-making because it helps stimulate a dialectical debate and promotes democratic decision-making. Program documents and the implementing entities may not specify whether decision-making involves input from or discourse with a diverse group of stakeholders and consideration of multiple social, economic and political factors. Diversity of input is important in decision-making because it promotes the flexibility to consider the needs of those who are not in power positions.

The third method—empirical analysis—allows examination of the mental models or cognitive maps held by those who are in the programs (Leeuw, 2003). These maps are compared and contrasted to measure their effectiveness through the use of open discussions and reviews of relevant research. “Managers, shareholders, stakeholders, and workers have “cognitions” (or “mental maps”) about the

organization and its environment (Leeuw, 2003, p. 14).” One of the strengths of this method is that it highlights the importance of observing managerial behavior in critical circumstances (not only in times of success). Confronting issues publically and making an effort to resolve them publically as well enhances transparency, which increases the likelihood of conflict resolution. However, a weakness of this method is that the empirical analysis will not always be clear about the knowledge bases and about the criteria used. Therefore, it is difficult to obtain empirically correct assumptions that are both efficient and effective. “All three approaches make the program transparent, allowing the evaluator and others to see how it is supposed to work (Newcomer et al., 2015, p. 70)”; or thought to be working from many perspectives (Leeuw, 2003). However, as discussed in Chapter 2 (Methods), only the policy-scientific approach was used in this study.

Managers should be able to present a logical argument for how and why a particular program is addressing a specific problem; they should also be able to explain how measurement and evaluation will assess and improve program effectiveness (Newcomer et al., 2015). Managers do not always have clear and consistent answers to the problems, but evaluation methodology is a logical attempt to resolve this issue.

Research Questions

The following research questions are presented in order to better understand the underlying assumptions in support of program policies, the application of program logic, and the role adaptive management plays within the TMDL process:

1. How, if at all, does the TMDL help the Chesapeake Bay watershed managers achieve their goals?

2. Do watershed managers recognize the essential role of adaptive management practices in the Chesapeake Bay TMDL?
3. Is the Chesapeake Bay TMDL a successful example of adaptive management?

Chapter 2

METHODS

To answer the research questions, I conducted a mixed method approach, consisting of quantitative environmental data analysis and semi-structured interviews. Collecting complimentary data, sharing the same research questions, and conducting equivalent analyses is essential to the mixed methods research approach (Yin, 1984). Mixed methods design answers research questions that cannot be answered by quantitative or qualitative approaches alone (Creswell & Plano Clark, 2011) and allow for a comprehensive analysis of the problem (Creswell & Plano Clark, 2011).

The methods described in this section were intended to facilitate an evaluation of the Bay TMDL implementation process and the role of adaptive management strategies in that process. As such, it constitutes a single-case study (Yin, 1984) of the Chesapeake Bay, with the evaluation of management strategies and the efficacy of TMDL plans implemented in the Chesapeake Bay watershed. The single-case study approach allowed evaluation of program plan performance through measurement of the success in meeting or exceeding specific water quality standards. In essence, I undertook a program evaluation using the methods suggested by Hatry (2006) and Wholey et al. (2010), explaining the reasons underlying the program, and using performance information from interviews to systematically assess indicators of program outcomes. In this research, the quantitative data collection and analysis occurred before the qualitative data collection and analysis.

The policy-science approach to program evaluation was employed because it allowed me to focus on how the Bay TMDL programs are supposed to work. This approach is more empirical than strategic assessment and empirical analysis and provides a series of propositions through relevant review of research, interviews with key staff members, and document reviews (Newcomer et al., 2015). As discussed by Wholey (2006), the policy-science approach provides superior insight into programs' objectives and priorities than the other approaches; for the present project it provide insight into the effectiveness of the TMDL plan across watersheds, which was tested through interviews and literature review. This method also allows a researcher to understand the motives behind programs that address social, organizational, and policy problems (Leeuw, 2003). It also is consistent with my desire to gain a strong connection with staff members, program participants and stakeholders. Finally, the policy-scientific approach allowed me to focus on data collection, organization of the data for analysis, and the interpretation of the findings, which explains whether adaptive management within the TMDL plan has been evident.

Quantitative Data Collection & Analysis

The first step was quantitative data collection. Quantitative data was obtained from the Chesapeake Bay Program's (Chesapeake Progress), an online resource for public access to the Chesapeake Bay's progress toward goals and outcomes of the Chesapeake Bay Agreement. This online resource provides water quality standards attainment and monitoring reports that document trends in nutrients and sediment in the watershed over time. Data of phosphorus, nitrogen, and sediment loads were obtained for the years from 1985 to 2016, with projections through the year 2025. From this data several years were selected to focus the analysis: 1985 was chosen as it

was the first year TMDL loads were measured; 2009 reflects a revised TMDL; 2016 is used as an indicator for the present state. The year 2025 was used as the terminal year in the analysis because it is the final accountability year for the Chesapeake Bay TMDL. The data was stored in an excel sheet and was organized in tables and charts for further analysis. The nutrients were then analyzed using an annual percentage change formula:

$$\text{Annual \% change} = \left(\frac{\text{ending number}}{\text{beginning number}} \right)^{\frac{1}{\text{years difference}}} - 1) * 100$$

Annual percentage change was calculated in order to examine the reduction percentage per year for phosphorus, nitrogen and sediment. Years 1985 to 2016 were first calculated using the percentage change formula, and then years 2016 to 2025 were extrapolated using the annual percentage change formula to assess where the Chesapeake Bay should be in order to meet targets.

Though Pennsylvania, Virginia, and Maryland each contribute substantial loads to the Chesapeake Bay, it was decided that an examination of Pennsylvania and Maryland would provide a good representation of the issues confronting management of the Bay and would allow more resources to be dedicated to each of those two states than if all three states underwent detailed analysis. Pennsylvania was selected because it is the largest nutrient and sediment contributor to the Chesapeake Bay watershed. Maryland was selected over Virginia because Maryland provides exemplary water quality efforts and was the first state in leading the Chesapeake Bay restoration.

Qualitative Data: Interviewing

Semi-structured interviews were used to gain further understanding of the knowledge and perceptions of TMDL plan implementers and stakeholders. Quantitative data collection and analysis discussed previously was used to assist in the development of primary interview questions. Interviews were used in order to gain a better understanding of the structure and variation of the program throughout the watershed and the relationship between expectations and experience.

The qualitative data consisted of semi-structured interviews (see Appendix A for interview protocol) of federal managers, state managers, nonprofit staff, and local participants of the Bay TMDL. More specifically, individuals associated with the Chesapeake Bay Program, Chesapeake Bay Foundation, Waterkeepers Chesapeake, Chesapeake Bay Commission, University of Maryland Center for Environmental Science, the Maryland Department of Agriculture, the Maryland Department of the Environment, the Department of Environment of Pennsylvania, and Department of Agriculture of Pennsylvania were subjects of the study. Additional stakeholders from the agricultural sector involved in the Bay TMDL were interviewed as well, as agriculture contributes the most nonpoint source water pollution to the Bay. I chose these organizations and stakeholders because of their involvement in the decision-making of the Chesapeake Bay TMDL. A total of 18 participants were interviewed, which provided a sufficient sample for conducting qualitative data collection (Creswell & Plano Clark, 2011).

I recruited interview subjects by email (see Appendix B) that included information about the intent of my research and the time required for the interview. The interviews took place from November 2017 to February 2018. Interviews were conducted to gain first-hand knowledge from program staff members, participants, and

stakeholders involved in the Bay TMDL. They were then transcribed, categorized and interpreted to extract the reasons the participants hold their beliefs and perceptions about adaptive management in regards to the Bay TMDL (Maxwell, 2005). Further, I obtained information on the events taking place within programs, how the participants made sense of those events, and how their understanding influenced their behaviors on the program outcomes (Maxwell, 2005).

The interviews facilitated a broader outline of questions as well as open dialogue for wider perspective (Wholey et al. 2010). Leeuw (2003) described interviews as argumentational analysis, which validates the reconstruction of the social, organizational and policy problems, as well as an understanding of the underlying theory through dialogues with staff members and stakeholders.

The semi-structured interviews had questions that 1) were worded in a way that respondents would understand and 2) allowed me to approach the question from the interviewee's perspective (Berg & Lune, 2012). Semi-structured interviews are valuable because researchers gain a better understanding of the conditions necessary to develop basic questions but not enough understanding to forecast reactions (Richards & Morse, 2007). More importantly, interviewees typically work in a fast-paced and collegial environment, where formal interviews may be less efficient and effective (Patton, 2013). The question responses provided information and insight into the decision-making process as well as highlighted the possible reasons behind any ineffectiveness of the TMDL plan. The questions were intended to capture the program process and collect information on the hypothesized linkages in order to examine or test the underlying assumptions (Wholey et al., 2010). The primary purpose behind the initial questions of the interview was to initiate a dialogue between

the interviewer and interviewee. This allowed the researcher to probe questions during the interview. The responses were combined as a part of the data analysis process. Questions for the semi-structured interviews can be found in the interview protocol in Appendix A.

Each interview lasted 15 to 60 minutes, depending on the follow-up questions. As the interviews were being conducted, the researcher made notes as a way to emphasize or question certain statements made by the interviewee.

The interviews were audio recorded using a recording device, and then uploaded into Trint, a software program that allows transcription and editing. Next, transcriptions were converted into a Word document and uploaded into software, Atlas.ti, for analysis. Atlas.ti is computer-assisted qualitative data analysis software that uses both open and axial coding (Woolf & Silver, 2018). Open coding was used to add depth to responses gathered from the axial coding process as well as to validate the responses from interviews. Atlas.ti was employed as a way to categorize, tabulate, and recombine qualitative data analysis (Yin, 2009). Further, thematic analysis was conducted to identify major themes emerging from the interview transcripts. Each interview in the software was identified as a “document,” which is a collective term for representing the data. Each document was scanned for initial “codes” in the form of words, phrases, sentences, and paragraphs. These codes were created as a way to identify ideas, concepts, theories, and issues relevant to the research phenomena. The name of the code was identified by the researcher based on the context of the response provided by the interviewee. The codes were put into categories based on commonalities or similarities. The categories allowed the researcher to condense the data into manageable amounts, which allowed the identification of themes. The

method of discovering themes is particularly critical to identifying underlying reasons behind ineffectiveness or inefficiencies, and therefore is embedded in the data (Mayan, 2009).

Permission & Confidentiality

The interview guide, recruitment letter, interview protocol and consent form were reviewed and approved by the University of Delaware's Institutional Review Board (IRB). All participants in this study were provided with an informed consent letter (see Appendix C) before the interviews were conducted. The purpose of the informed consent letter was to introduce research interests and efforts, indicate the intent of the study, and disclose that participation in the study is voluntary. The informed consent letter indicated that the recipients' background information would remain confidential and would not be accessible without his or her approval. All participants were required to sign and return the consent form prior to participating in the study. The informed consent protocol had the added benefit of helping to gain the trust and support of participants.

Chapter 3

ANALYSIS & RESULTS

The objectives of this study were to explore adaptive management's role in the implementation of the Chesapeake Bay's TMDL. Gauging the understanding of the implementation of the Bay TMDL allows understanding of inefficiencies or ineffectiveness behind meeting water quality standards. The understanding behind adaptive management and the TMDL effectiveness was measured through both quantitative and qualitative data analysis. The majority of this thesis focused on semi-structured interviews and analysis of the interviews.

Quantitative Data Analysis & Results

Table 1 shows the loads of nutrients and sediments in millions of pounds simulated by the Chesapeake Bay model for years 1985, 2009, 2016, 2017, and 2025. The data are based on monitoring of the loads, and the 2017 and 2025 projections were calculated based on these loads. Data analysis suggests that Pennsylvania, Virginia, and Maryland contributed 91 percent of Chesapeake Bay watershed nutrients and sediment in 1985, 2009, and 2016. Data analysis further suggests that if the historical average annual reduction percentages for phosphorus and sediment loads (1.635% and 0.995%, respectively) continues until 2025, their loads will be lower than that targeted (0.68% and 0.84%, respectively) (see Figure 1 & Figure 2). However, on average, the historical annual reduction rate for nitrogen is only about 1.2%, and in

order to meet the 2025 target, that percentage must double to 2.4% annually (see Figure 3).

Table 1: Nutrient and sediment loads to Bay simulated using CBP model. 2025 Planning Targets were established for development of Phase II Watershed Implementation Plans. Source: CBP.

	1985	2009	2016	2017	2025
Nitrogen (millions of pounds)	369.78	282.66	257.64	237.61	207.57
Phosphorus (millions of pounds)	25.62	19.23	15.37	16.37	14.46
Sediment (millions of pounds)	10,798	8,675	7,920	7,874	7,341

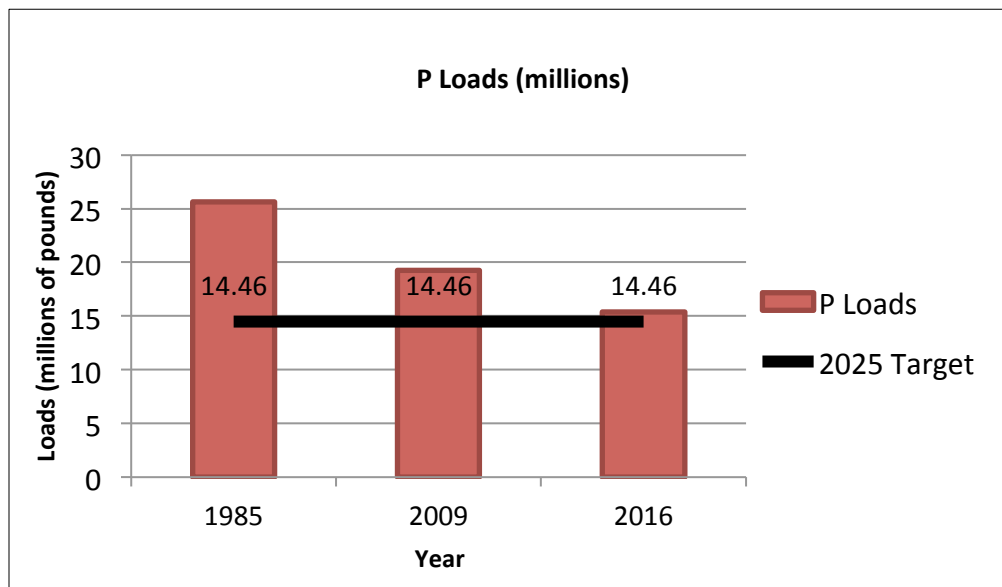


Figure 1: Phosphorus loads in millions of pounds; years 1985, 2009, and 2016. Simulated using 5.3.2 version of Watershed Model and wastewater discharge data reported by Bay jurisdictions. Source: CBP.

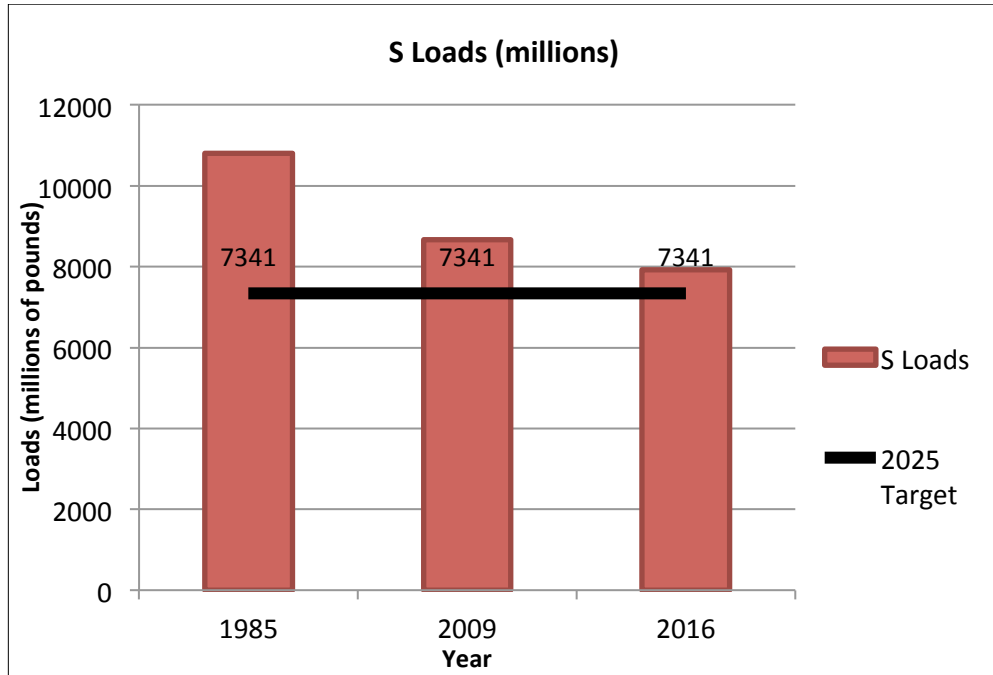


Figure 2: Sediment loads in millions of pounds; years 1985, 2009, and 2016. Simulated using 5.3.2 version of Watershed Model and wastewater discharge data reported by Bay jurisdictions. Source: CBP.

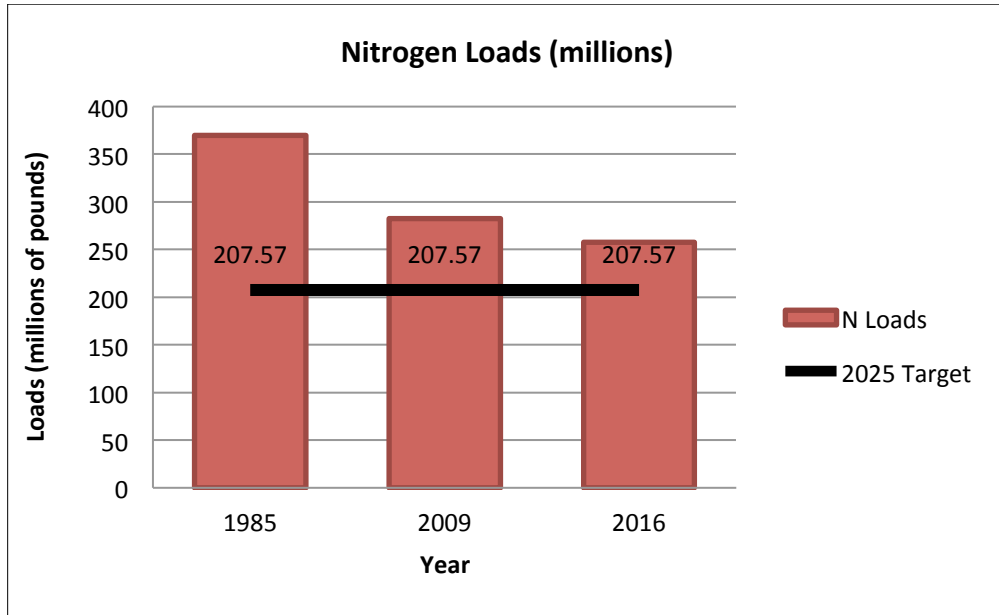


Figure 3: Nitrogen loads in millions of pounds; years 1985, 2009, and 2016. Simulated using 5.3.2 version of Watershed Model and wastewater discharge data reported by Bay jurisdictions. Source: CBP.

The quantitative data analysis on phosphorus, sediment, and nitrogen indicates that there is a need for better understanding of implementation of the Bay TMDL, which I now turn to.

Qualitative Data Analysis & Results

Interviewees consisted of: 7 federal, 3 NGO, 1 academic, 4 farmers, 1 local municipal representative, and 2 state representatives. The initial pass through all 18-interview transcripts resulted in a total of 1,228 codes. Each of these codes was further defined by the topic or category being discussed and put into 48 categories. Next, quotes were pulled from interview transcripts to illustrate the major themes. The three major themes identified during the interview analysis are, 1) the effectiveness of

implementation of the Bay TMDL; 2) adaptive management used within the implementation of the Bay TMDL; and 3) communication, involvement, and engagement. Within each of the major themes, subthemes were identified to further understand the reasons for responses to questions. Themes and subthemes are presented and the number of codes that were categorized into each theme is set forth in Table 2.

Table 2: Major themes and subthemes identified during qualitative analysis; computer-assisted software, Atlas.ti, used for assistance.

Theme	Subthemes	Number of Codes
Theme 1: Effectiveness of implementation of Bay TMDL	<ul style="list-style-type: none"> • Partnership & Accountability • Modeling & monitoring • Non-tidal state 	138
Theme 2: Adaptive management used within implementation of Bay TMDL	<ul style="list-style-type: none"> • Knowledge & understanding • Recognizing adaptive management's importance 	825
Theme 3: Communication, involvement, & engagement	<ul style="list-style-type: none"> • Intergovernmental relations • Partnership role in management • Engagement of nonpoint source communities 	265

Theme 1: Effectiveness of Implementation of Bay TMDL

Effectiveness of the implementation of the Bay TMDL was identified as a theme based on responses participants provided during interviews. A total of 825 codes were identified under the effectiveness of the implementation of the Bay

TMDL. This is important because it allowed the researcher to understand inefficiencies or ineffectiveness behind the Bay TMDL.

1. Partnership & Accountability

The first subtheme identified here is partnership and accountability of the implementation of the Bay TMDL. As previously noted in the quantitative data analysis, trends of phosphorus, nitrogen, and sediment loads are fluctuating. While phosphorus and sediment are on track to meet their final goals, nitrogen will need to double its percentage reduction rate to meet its 2025 goal. To probe this data, interviewees were asked whether, and if so, how the Chesapeake Bay TMDL implementation is effective. A common interviewee response in identifying strengths is the EPA's ability to hold states accountable for their actions:

... One of the reasons why the TMDL has been successful is because the EPA has been willing to hold the states accountable, and that could be if you look back at the state or the EPA has evaluated the states progress on what they call the two-year milestones... - Interview #1, Chesapeake Bay Foundation

Another interviewee suggested that effectiveness stems from the tension between the federal and state government:

You need that positive tension between the federal government and the state government. Obviously within the legal limits of the Clean Water Act, but yes, having that tension there is helpful to moving things along. We're all human, right? We all need a little bit of incentive to move things along, so yes, it has been helpful. – Interview # 9, Chesapeake Bay Commission

This emphasizes the need for both federal and state authority in order to enable accountability, and to evaluate and assess by enforcing two-year milestones. Under the Chesapeake Bay Program's accountability framework, two-year milestones were created as a way for jurisdictions on the Chesapeake Bay watershed to assess their

progress toward meeting water quality standards. States are required to make commitments and meet them every two years. It has been shown that federal authority over states provides greater resources and participatory capacity than local governments and other institutions (Cosens et al., 2017).

Another interviewee from the Maryland Department of Agriculture expressed that another strength of the implementation of the TMDL arises from the Partnership among all the jurisdictions of the Chesapeake Bay watershed. He also recognized the EPA's regulatory position as a strength:

The biggest strength that I feel that we have with the Bay TMDL and the Chesapeake Bay Program as a whole, is that it is truly a partnership among all of the stakeholders and jurisdictions that are involved in this. There's a recognition that we all need to do our part to restore the Chesapeake Bay and the EPA has the ability to hold the jurisdictions accountable for their implementation, or lack thereof, in achieving the Bay TMDL. I would say it's the overall governance and management of the TMDL, that's the strength and having that oversight provided by the Bay Program Office. – Interview #18, Maryland Department of Agriculture

Though the EPA is claiming to hold states accountable for their actions, there seems to be a concern with the EPA's follow-through in their regulatory role. As such, weaknesses of the implementation of the Bay TMDL were identified as well. For instance, an interviewee, scientist and current professor at the University of Maryland, questioned the EPA's commitment to its regulatory charge. Pennsylvania, in particular, has been lagging in meeting their water quality goals; but they have not received any sanctions or admonishments for their failures to meet targets.

... What is the enforceability? We say these are mandatory and legally required. The states don't achieve those results, say Pennsylvania, which is woefully behind schedule. What's going to happen? Will EPA follow through on the threats that can impose backstops, or take away regulatory authority? And even if they did, would that accomplish the

end result? -- Interview #6, University of Maryland Center for Environmental Science

Other interviewees concurred. For example:

Pennsylvania was the biggest challenge, and I think there was some things along the way that my agency didn't step up and commit to do with Pennsylvania that we should've early on, because we laid it out pretty much in writing, saying, "If you're in good shape, you're on the right trajectory, we're going to leave you alone and complement you, and then step out of your way and let you do your stuff. If you're failing to do it and you're failing miserably, then we're going to step in and in fact make life a little bit uncomfortable with you." -- Interview #2, Chesapeake Bay Program

The failure to meet TMDL goals affects the outcome of water quality standards. The EPA did not hold Pennsylvania accountable for failing to meet their goals. It is not quite clear that the federal government is fulfilling its responsibility to hold states accountable, and this is making it difficult for other jurisdictions that are actually meeting their TMDL goals. Integration of federal governance reduces the possibility of unintended consequences and increases the likelihood that conflict will be addressed proactively (Cosens et al., 2017). In this case, the possibility of unintended consequences is greater because the EPA is not holding states accountable for their failures. However, under the CWA, the US EPA does not require states to regulate nonpoint sources (Aiken, 2017). Whether or not this should change is in question.

Additionally, interviewees working for the Chesapeake Bay Program claimed they have attempted to work with state and local officials in Pennsylvania more than those in other jurisdictions given that Pennsylvania is behind their goals. Further, Pennsylvania did not follow up with the offered assistance; and even with that offered assistance, there still seems to be a lack of effort in Pennsylvania in adopting strategies and approaches to meet TMDL targets. Thus, another weakness in the effectiveness of

the implementation of the Bay TMDL is the lack of willingness from stakeholders. However, it should be noted that many local governments exercise management and regulatory authority but are structured very differently. This likely leads to lack of understanding (Cosens et al., 2017). To emphasize this point, a farmer stakeholder claimed that a majority of farmers are actually not willing to implement TMDL practices:

But again the TMDL, in total, doesn't mean that much to farmers on the ground because their primary concern is continuing to farm and being able to make a living at it. It's not the TMDL. – Interview #8, Maryland Farmer

Various interviewees brought up matters which highlight major sources of ineffectiveness in the implementation of the Bay TMDL. For instance, one interviewee mentioned that one of Pennsylvania's issues with meeting the Bay TMDL is their lack of understanding the context of the TMDL itself; it may also express that the TMDL is not a priority in farming practices.

... If you're farming and you don't have the data to understand what's happening, it's very difficult to make management decisions and I think Pennsylvania is in that same situation at times. -- Interview #16, Agricultural Technical Coordinator (and working farmer), Chesapeake Bay Program

2. Modeling & Monitoring

Farmers, in particular, may have difficulty understanding the TMDL because they have not seen the quantitative data of nutrients and sediments. Moreover, there is not only difficulty in understanding ways in which the Bay models operate, but there are also different interpretations of modeling and monitoring. There thus seems to be a lack of science communication between farmer stakeholders and water managers. Therefore, the second subtheme derived within this theme is modeling and monitoring.

Further, interviewees touch on the difference between monitoring and modeling. It can often be difficult to communicate the difference. Monitoring data requires a day-to-day calculation of the loads in the Bay, which are then inputs into models in the Bay to predict projections for the future. There is clearly a large contextual misunderstanding of the data and its everyday work for the TMDL. Further, stakeholders have a hard time understanding that the monitoring data is being used to make predictions for the future. For Pennsylvania, the modeling and monitoring context poses most difficulty in understanding the TMDL:

... That is a hard one to communicate to the public because modeling really is intended to be a planning tool. Models help us look into the future... the monitor data is what we know is happening here and now and the model takes that and predicts the future.– Interview #9, Chesapeake Bay Commission

An interviewee expressed the importance of improving the monitoring and modeling of data as a way to help Bay states meet their cleanup commitments; he also mentioned the importance of incorporating stakeholders in the process of understanding monitoring data so as to develop strategies to meet TMDL goals. This is an example of how modeling and monitoring can be improved so as to increase understanding:

I think we're doing the best that we can. But I think, yes, certain things can be improved upon which is what we've been doing the past five years trying to improve our modeling tools and trying to do a better job of incorporating monitoring data into helping the states plan their or develop their strategies. Are there more partners that we can engage? Yes. Could we incorporate other non-water quality watershed agreement outcomes? Yes. – Interview #3, Chesapeake Bay Program

Though the Bay TMDL models are predictive, there seems to be some skepticism about what data managers are observing and estimating from the models.

For instance, an interviewee stated that relying on the models for expectations is a constraint because it is not completely accurate data.

... The Bay program is running hot and cold on one side or the other, and it's largely emphasized the expectations that is the models. And it's relied on as estimations of progress - how far we are along - based on estimations by models rather than actual observations. – Interviewee #6, University of Maryland Center for Environmental Science

3. Non-tidal state

The third subtheme here is non-tidal state, Pennsylvania. With that, it is important to understand the central role of human behavior in determining outcomes:

Pennsylvania is really struggling; they're pretty far behind. And that's for many reasons. I would say a lot of it is that they don't have tidal waters and what the actions that we're doing are to affect the water quality standards in the tidal waters. – Interview #12, Chesapeake Bay Program

Further, when asked if an interviewee thinks that being a non-tidal state on the Bay watershed has anything to do with the state's contribution to cleanup commitments, this was the response:

I think that for all of the states that don't view themselves as having a relationship with the Bay, it is more difficult for them to understand why they're cleaning up the Bay. – Interview #13, Waterkeepers Chesapeake

This suggests that Pennsylvanians may have a difficult time understanding their part in meeting WQs on the Bay watershed and in relating their actions back to the watershed as a whole. Alternatively, or perhaps concurrently, farmers may be resisting TMDL implementation.

Nevertheless, one of the interviewees who farms in Pennsylvania did recognize that the Susquehanna River flows into the Chesapeake Bay, and thus, contributes to the loads in the Bay.

That stream goes into the Susquehanna River, which flows into other creeks before it gets to there, but eventually goes to the Susquehanna River, which is the most influential River in the Chesapeake Bay. That's why we're in the Chesapeake Bay watershed. – Interview #17, Pennsylvania Farmer

Another noticeable constraint is the lack of effective dialogue. In particular, there is a lack of community-based collaborative exchange to address water allocation, quality, and management. Further, there are communication gaps resulting from the lack of coordination among interstate governmental bodies – those on the federal, state, and local levels. Both citizen and science bodies will easily lose trust if they lose a sense of well-rounded understanding and knowledge essential to the effectiveness of the Bay TMDL. All knowledge has value, but the capability to express that knowledge in a sensible, understandable way seems the largest concern, affirming the reason behind failing to meet TMDL goals and targets.

Theme 2: Adaptive Management Strategies Used Within the Implementation of the Bay TMDL

The second theme focuses on the extent to which adaptive management is used as a strategy in the implementation of the Bay TMDL. In the natural resource context, adaptability is largely driven by change (Doremus, 2010). Based on the evaluation of the working definition of adaptive management and criteria that support it, interviewees generally recognized its essential role.

1. Knowledge & understanding

Below are general examples of interviewees' response when asked to define adaptive management:

Adaptive management means managing based upon some expected outcomes with a rigorous system to measure the outcomes and with a structure to make changes in the actions taken, in order to achieve the desired outcomes, based upon those measurements and assessments of those measurements. -- Interview #6, University of Maryland Center for Environmental Science

Adaptive management in its true sense, in my mind means putting into practice different implementation techniques, different understandings of science, putting them out in the field, in action out there, watching the system respond, and gauging that response, and how it matches with your intended response, your intended objectives. – Interview #2, Chesapeake Bay Program

Interviewees recognize that adaptive management is required to be used in the management of the TMDL because the environment is constantly changing, and it requires adaptive management to complement those changes.

You're going to have to change the management strategies because conditions don't remain the same. In an ecological system - really in any sort of system - they really can change overtime, but particularly when you're looking at something like river management or ecological management, the conditions change. – Interview #13, Waterkeepers Chesapeake

Though interviewees had a general understanding of adaptive management, not one of the eighteen participants included stakeholder involvement or stakeholder engagement in their definitions.

After interviewees were asked to define adaptive management, they were asked to provide examples of adaptive management they have seen on the Chesapeake Bay watershed, or examples of adaptive management they have used or have seen being used in the implementation of the Bay TMDL. An interviewee's response follows:

The two-year milestone process is probably the most relevant example I can think of because again they have these larger watershed implementation plan documents that at one point covered 2010 to 2025.

But obviously, all the years in between things are going to change. New political administrations, again, new scientific data monitoring information that might instigate some change in course of action. Jurisdictions use those two-year milestones to update some of their programmatic or numeric commitments. – Interview #3, Chesapeake Bay Program

The WIP's are intended to ensure that jurisdictions make progress by keeping their cleanup commitments. The two-year milestones act as interim targets and provide an opportunity to assess continuing progress based on current progress. This approach is embedded in the CBP's management strategy, but stakeholders and managers involved in the implementation of the TMDL are evidently lacking the understanding of engagement and involvement inherent to adaptive management. Adaptive management in the problem-solving context requires "resources to monitor and analyze information that tests not only the immediate results of management actions, but also the underlying assumptions of those actions, to facilitate a process" (Cosens et al., 2017). Further, policymakers, regulators, and managers are responsible for giving special attention to inform adjustment, involving both the consideration of science and socioeconomic factors. This involves setting goals and policies in building collaborative relationships.

2. Recognizing adaptive management's importance

Interviewees did acknowledge that adaptive management, if properly implemented, could generate significant benefits to the TMDL program. Program flexibility, a hallmark of adaptive management, is essential in order to adapt to our changing economic, political and social environment based on measures and outcomes. Moreover, adaptive management is well suited for uncertainty and uncontrollability, which is relevant to current ecological events.

Most interviewees are finding that adaptive management is necessary to respond to the changing environment; however, they are also recognizing that the changing environment is impossible to predict or manage. Below are excerpts from two interviews where the importance of being adaptable to the changing environment was discussed:

... Not only do you have to reach your goal, you have to maintain it. How we maintain that moving after 2025 is going to take a lot of commitment and it's going to take adaptive management... – Interview #16, Agricultural Technical Coordinator, Chesapeake Bay Program

Not holding back some of the nutrients and sediment is going to be a big problem. Growth is going to be an issue. We have to deal with all those things at the same time we're dealing with just trying to reduce the pollutants in general. That's going to be our challenge and it's going to be a real challenge to meet it by 2025. – Interview #12, Chesapeake Bay Program

Cosens et al (2017) touch on the importance of understanding timeframes for adjustment in order to account for both biological and social concerns, which may aid in striking balance among the goals of social and economic stability.

An interviewee discussed the importance of utilizing adaptive management and the willingness within water management in the various jurisdictions to be flexible to change course when needed:

I think that's a really prominent example of being willing to change course, acknowledging that there's new information; there's things that we didn't consider before, and then being willing to change our management, outcomes or allocations based on that new information.– Interview #1, Chesapeake Bay Foundation

The federal government must recognize the need to, and must possess the political will to, adapt; and also must be reminded that adaptive management has been utilized since the TMDL was introduced:

Adaptive management has been there, I feel pretty much the entire time - I think it's greatly expanded, much more emphasized partially is because that in order to address the water quality goals the TMDL that I think most of the partners have identified that just doing the basics will not be sufficient. We are going to have to go beyond the basics of whether it will be the urban or agriculture or other sectors to achieve those goals. – Interview #12, Chesapeake Bay Program

Another interviewee added adaptive management as an asset of the TMDL because it requires a management approach that utilizes measures to assess whether actions are succeeding, and then changes that management approach to fulfill expectations:

But what it is in my mind in practice is that you set up a way to test what you're doing as you're doing it, so it usually involves having measures of success - that you're measuring - so you do the actions, you have a measurement to see whether the actions not only are getting done, but they're having the impact up to your goal that you're expecting to have. And if it's not, then you figure out why it's not and you change the way you're managing. –Interview #12, Chesapeake Bay Program

Another interviewee discussed the use of adaptive management within the TMDL initiative. Adaptive management is used in various sectors of the TMDL, including the modeling and monitoring workgroups. The modeling and monitoring workgroups assess data and evaluate changes based on models. Their daily calculations and rigorous measures are used for policy changes.

It could be used as a theme; a touchstone; as something to you know maybe be fit in - but adaptive management really in the Bay Program is lived and breathed with the modeling workgroup the group that I coordinated and most involved with that is to say we solve problems of the decision makers in the Bay program. – Interview #10, Data Manager, Chesapeake Bay Program

However, another interviewee brought up a weakness of adaptive management used in the context of the TMDL:

Adaptive management in a regulatory context is really hard to do and because regulations were not meant to be flexible. -- Interview #12, Partnership & Accountability Office, Chesapeake Bay Program

This is recognized as a weakness because the EPA's dissemination of the TMDL plan entails enforcement regulations and policies that are inflexible. Adaptive management, however, it intended to be flexible, as management adapts to complex environmental changes. It also is iterative, with the capability to adjust based on goals, data, and outcomes.

The Chesapeake Bay program has adopted adaptive management as a way to guide states in their implementation strategies. Ultimately, the TMDL itself is not changing, but the way that it is being implemented is changing over time:

Adaptive management requires a lot of data to be able to do it right and a lot of willingness to look at the data and change what you're doing. And we get caught just like everybody else does and not being able to change even when we're learning new things. But I think we're as flexible as we can be in a regulatory framework to be able to do adaptive management. – Interview #12, Partnership & Accountability Office, Chesapeake Bay Program

Communication is key in decision-making; any gaps resulting from the lack of overlap in implementation with interstate bodies diminish any capability of enhancing adaptive responses (DeCaro et al., 2017). An interviewee recognized that adaptive management itself is not a challenge, but the ability to emphasize its importance to other jurisdictions is problematic. There must be a common understanding and willingness to act for all those involved in the implementation of the TMDL, in order for goals to be met – and it takes adaptive strategies to maintain those goals.

Being able to be adaptive to the different viewpoints just from the jurisdictions is part of the challenge but part of what needs to be done and part of being open and flexible with being able to do that... That is the challenge - that the Bay Program Office will be able to listen and understand and adapt, and we have to do our best to facilitate this

conversation between the various parties. – Interview #16, Agricultural Technical Coordinator, Chesapeake Bay Program

This is further supported by a quote from a farmer in Pennsylvania, who is aware of the TMDL plan and uses Best Management Practices (BMPs) to contribute to conservation stewardship. However, this interviewee was not familiar with the term “adaptive management,” and therefore, was not able to provide any context or examples:

We would probably not use that, but we – our management philosophy is that we want to do the best job to make money, obviously, so we can stay in business. But, we also are very conscientious about the environment. Whatever it takes to farm, to make our farm better but stay firm of improving the environment; that’s our philosophy. – Interview #17, Pennsylvania Farmer

Often, knowledge gaps in management can undermine decision-making. Actions in the midst of uncertainty will move a system away from its goals, with public scrutiny resulting in claims that are not following science (Doremus, 2010). Lack of collaboration and knowledge gaps in adaptive management leads to decreased optimization of water quality improvement; this, in turn, increases system vulnerability to climate change (Cosens et al., 2017).

Theme 3: Communication, Involvement, & Engagement

The third theme – communication, involvement, and engagement – was identified as an important theme to explore based on the interview discussions. Communication and engagement facilitate decision-making, especially in the face of environmental change. Subthemes were also identified for further investigation as potential reasons behind ineffectiveness and inefficiencies of the Bay TMDL: intergovernmental relations, partnership role in management, and engagement of nonpoint source communities and those communities willingness to engage.

. For any policy, the active involvement and engagement of both governmental entities and stakeholders is critical to the process of effectuating change. A majority of interviewees expressed the opinion that communication is the most difficult aspect of TMDL implementation. In particular, because the Bay watershed is comprised of seven jurisdictions, communication among them is extremely difficult to facilitate. There is a defined scope of communication between Bay watershed jurisdictions through workgroup meetings, alliance meetings, conference calls, etc. However, the communicated message is often perceived differently, making it difficult for respective jurisdiction representatives to effectuate any changes within their states.

1. Intergovernmental relations

The first subtheme is intergovernmental relations. There is a recognized need for governmental entities to collaborate with one another – this need applies to federal, state, and local governance levels. The EPA has the authority to implement the CWA; and the states are responsible for coordinating and organizing the cleanup and management efforts of their local governments and collaborating with the other state jurisdictions in achieving established pollution reduction targets.

Intergovernmental collaboration depends on the ability to enforce TMDL measures in a way that is understandable to state and local governance. There can be tension between watershed managers comfortably effectuating change on the one hand, while remaining consistent in their implementation of the program on the other. For instance, one interviewee expressed the challenge of achieving common understanding among different administrations when they have differing perspectives:

You have different administrations who have different policy views... getting them to come to consensus when they're coming at issues from completely different perspectives is not an easy-- that's a big challenge.

– Interview #5, Partnership & Accountability Office, Chesapeake Bay Program

However, an interviewee claimed that the federal level was working successfully with the state level of government:

The feds working with the states to implement such a very comprehensive plan particularly across state political boundaries. It's been remarkable. – Interview #3, Chesapeake Bay Program

Further, another interviewee expressed the advantage of some tension between the federal and state governments:

You need that positive tension between the federal government and the state government. Obviously within the legal limits of the Clean Water Act, but yes, having that tension there is helpful to moving things along. – Interview #9, Chesapeake Bay Commission

Here, an interviewee expressed the need for federal authority to hold state governments accountable for not meeting targets:

...to then make states or agencies accountable for those loads, and who's going to be responsible for what level of reduction over time, who's going to pay for it, do you have the regulatory, do you have the ability to control those loads, or if they are not regulated, is there some way that a state or local entity can still work to get those. – Interview #2, Chesapeake Bay Program

An interviewee further emphasized the need for federal oversight and stakeholders recognizing the mandates of the CWA:

The citizens are more able, "Hey, we have to do this. There's now a federal mandate now." Then again, it's also their state's standards that have to be met. It's more of an emphasis to them. I think it just depends on the perspective. – Interview #15, Pennsylvania Department of Environmental Protection

This demonstrates need for coordination between federal and state agencies: identifying who is responsible for meeting targets and how these targets will be

achieved. An interviewee suggested that state governments have emphasized the importance of committing their localities to meeting TMDL targets:

We agreed to that, and then states adopted that into their state regulations, which essentially said, "Public, we're committing to meeting these levels of water quality in your rivers and streams in the Chesapeake. Once we attain those, then we are going to maintain that over time, as our obligation to you all as locals, state and federal government agencies out there". – Interview #2, Chesapeake Bay Program

The TMDL implementation is entirely at the discretion of watershed managers within states, but it is their responsibility to enforce measures within their localities. Unlike other portions of the CWA, such as regulating point sources, there is not clear responsibility for enforcing nonpoint source requirements.

2. The partnership role in management

In addition to government administrators at all levels needing to have the political will to work with one another, it is also important that all levels of government be willing to work with stakeholders throughout the process. Stakeholder engagement is critical in achieving the Bay TMDL for a number of reasons. First, decision-making often involves constructive dialogue between government and nonprofit organizations (Margerum & Robinson, 2015). Here, an interviewee underscores the importance of partnership:

I think what we've built here, partly regulatory, partly partnership driven, and the two melded together in trying to keep that balance between the regulated peace and that voluntary partnership, which is extremely effective. – Interview #2, Chesapeake Bay Program

However, another interviewee recognized the need to create a more meaningful level of engagement by EPA, states and non-governmental organizations:

EPA working with the states and other non-governmental organizations have been trying to answer those questions and how to how do we make stakeholder engagement more meaningful in the Phase III process, so they know what their contribution is; what role they have to play; Why it's important and how we can perhaps piggyback on other local priorities. – Interview #3, Chesapeake Bay Program

Similarly, a nonprofit manager identified the need to not only cooperate through the EPA's authority, but also that local governance must be willing to coordinate with the state and federal government.

We can do a lot through EPA's authority. But at the end of the day it's really going to take people who want to save their local streams at the Bay and have their actions be consistent with that desire. – Interview #1, Chesapeake Bay Foundation

When asked to provide benefits to the Bay TMDL, an interviewee spoke on the creation of the Bay Partnership. This interviewee further added the importance of the Partnership encompassing both authority and voluntary actions:

It wouldn't affect things that are outside of regulations and that's somewhat still a challenge. People identify the program had ties with EPA and it depicts decision-making and we can seriously have to remind folks that these are partnership decisions that are backed up by EPA. But, ultimately it's a partnership, it's a representation, it's making decisions about how to represent agriculture and how to represent conservation practices. – Interview #16, Chesapeake Bay Program; working farmer

Further, this interviewee added the importance of having federal oversight on the Bay TMDL, while also having the EPA act in its regulatory role and its partner role with state and local governments and organizations. There will always be a warranted need for federal regulatory oversight of Bay water quality.

3. Engagement of nonpoint source communities and those communities willingness to engage

The last subtheme embedded in this theme is engagement of nonpoint source communities (“community stakeholders”) and the willingness of those communities to engage. Community stakeholder engagement and willingness is critical to affecting change because for the TMDL to be effective, local communities must understand the benefits of nonpoint pollutant management, have the information at hand on how to realize such benefit, and be willing to participate and change course, as needed, in order to effectively pursue articulated objectives. Stakeholder support informs and drives public debate and policy.

Through stakeholder involvement and engagement, there needs to be greater understanding of the TMDL processes and objectives and the effect stakeholders have on the Bay watershed. One way to address this is by government/managers attempting to understand stakeholder behavior and opinions and responding in a way that is beneficial to the watershed:

I think what we really need to be doing more of is trying to figure out how we motivate, our citizens behavior change, and how we make sure how we educate them in a way that motivates them to take care and make their individual choices to be consistent with their commitment to water quality. – Interview #1, Chesapeake Bay Foundation

In particular, a farmer from Maryland highlighted the importance of bringing together diverse perspectives on an issue that affects them.

...Getting environmental groups, government, farmers, ag industry people together to discuss what the issues are - maybe not always agree on what should be done, but at least agree on what the information is that we're working from. And to that end that has not been done very well in the past. Everybody has a different set of facts that they're working from and that's not very good for trying to come to consensus... – Interview #8, Maryland Farmer

An interviewee recognizes that greater willingness needs to come from communities. In order to address nonpoint sources, stakeholders must act voluntarily:

...It requires a lot of voluntary participation and willingness from farmers and urban communities ... and that's a huge barrier.... How do you change behavior to result in a positive outcome and how do you engage those sectors and communities that really are responsible for implementing practices on the ground? – Interview #3, Chesapeake Bay Program

A lack of will stems from both a lack of understanding among Pennsylvanians, and the related difficulty in communicating to them how their actions affect nutrient loads in the Chesapeake Bay watershed because Pennsylvania does not border the Bay and much of the watershed in Pennsylvania that flows into the Bay is not tidally influenced:

“We have no Bay shoreline, we're not... a “Bay state” and that presents some challenges when we have to communicate to the citizens that we're doing this for the Bay, or we need to spend resources for the Bay. That doesn't mean anything to them. – Interview #9, Chesapeake Bay Commission

An interviewee added the importance of messaging the TMDL on a local level:

The folks in Pennsylvania aren't going to care that much about the Chesapeake Bay and what's going on down there. But they will care about this Susquehanna. And so protecting that waterbody is something they can relate to them. And protecting that waterbody also results in protecting the Chesapeake Bay... bringing it back to people's backyards and what's going on in their communities I think is very important because you get the same result. – Interview #13, Waterkeepers Chesapeake

Another interviewee suggested a reason for ineffectiveness of the TMDL, particularly in the agriculture community: there are no incentives for farmers to participate, leading to a lack of will. Farmers receive incentives for Conservation Stewardship Programs (CSP) from the government (“Conservation Stewardship Program”). These programs provide farmers subsidies for employing best management practices:

Traditionally, farmers have been apprehensive in implementing this type of practice because there's no direct benefit to them. They don't actually sell a crop from that so they're putting their cost as far as like seed and fuel, other things, tillage into these fields without getting a direct return or benefit from that financially. The state provides cost-share assistance essentially to pay the farmers to do this practice. – Interview #18, Maryland Department of Agriculture

There is room for improvement in stakeholder engagement; as there seems to be a disconnect in the understanding of the TMDL program, which may lead to the lack of involvement and engagement. In particular, it was found that several farmers did not have a clear understanding of the processes and objectives of TMDL. A farmer touched on causes of the accumulation of sediment in the watershed:

There was really a lot of sediment accumulated over the last hundred to hundred and fifty years behind them. That has contributed some, to the daily loading in the Chesapeake Bay. Some of that has been blamed on farmers, that isn't where the blame should be. That is one of the natural things; sort of natural things that happened that has affected some of the testing that has been done in the bay and has not been taking into consideration. – Interview #17, Pennsylvania Farmer

Chapter 4

DISCUSSION

The purpose of this research was to evaluate and assess the role of adaptive management in the implementation of the Bay TMDL, as well as assess its effectiveness. Quantitative data analysis may suggest inefficiencies behind implementation, and thus, semi-structured interviews were conducted to further probe possible inefficiencies.

For the purpose of the TMDL program evaluation study, policy-science approach was used because it allows for greater focus on how the programs involved in the Bay TMDL are supposed to work. As discussed by Wholey (2006), the policy-science approach provided greater insight into the program's objectives and priorities as well as the effectiveness of the TMDL plan across watersheds, which was tested through interviews and literature review. This method provided the opportunity to probe the motives behind the program that addresses social, organizational, and policy issues (Leeuw, 2003). It also afforded me a connection with staff members, program participants and stakeholders. Data collection, organization, and analysis, informed the interpretation of the findings related to the evaluation of adaptive management to the TMDL plan.

Summary Overview of Results & Discussion

Quantitative data analysis suggests that if reductions continue at the historical average annual reduction rate for phosphorus and sediment loads, the 2025 TMDL target will be met. However, the analysis also reveals the nitrogen load reduction rate lagging woefully behind its target.

Eighteen semi-structured interviews were conducted between December 2017 and January 2018. Themes and subthemes were identified from the interview transcripts.

Effectiveness of implementation

Data embedded in the interviews suggests much room for improvement in the implementation of the Bay TMDL. Though Maryland is finding success in their implementation measures and outcomes, Pennsylvania is failing to engage people to make improvements to meet standards.

Many interviewees shared the same response in recognizing strengths of the TMDL—the EPA’s ability to hold states accountable in theory. Jurisdictions are supposed to be using the accountability framework from the CBP, which helps them in assessing their progress in meeting goals and targets. It also acts as a reminder that the EPA will hold them accountable for failing to meet goals. However, an issue raised by interviewees is whether the EPA is holding states accountable in practice. For instance, Pennsylvania is underperforming in meeting its targets. However, the CWA does not require that states regulate nonpoint sources, which may explain why Pennsylvania is failing to meet its WQSSs. Moreover, although the EPA does have discretion in how to address nonpoint sources, it has so far chosen not to regulate them in an enforceable way. Given that nonpoint sources have contributed the majority of

pollutants in the Bay watershed, it would be appropriate for EPA to address them in a manner comparable to point sources; at the same time, defining comparable metrics will be challenging given that regulating nonpoint sources require different strategies than point sources.

A second strength mentioned by many interviewees is the creation of the Chesapeake Bay Partnership. The Bay Partnership consists of six states, the District of Columbia, the EPA, state agencies and NGOs. The Partnership among the jurisdictions and EPA creates a collaborative atmosphere necessary for effective decision-making. By creating mechanisms and infrastructure to share information and resources, the Partnership is better equipped to meet challenges in the face of the changing political, economic, and environmental circumstances.

A major concern raised by interviewees is stakeholders' ability to understand the implementation process of the Bay TMDL. It seems a large contextual issue stems from the modeling and monitoring of the TMDL. Scientists and managers are using day-to-day monitoring results, and creating models to make predictions about the future. Modeling and monitoring in turn is critical to furthering understanding of the TMDL because it allows stakeholders to assess their progress in achieving targets. There is however difficulty in a) understanding the monitoring-modeling dynamic, and b) assessing the predictive accuracy and limits to modeling technology, as models are not perfect predictors, and their limits are defined by the accurate recognition of correlative and confounding variables. Indeed, stakeholders at the local level lack understanding of the TMDL and/or the modeling-monitoring context of the TMDL.

Several factors lead to partial effectiveness of the TMDL program. To begin with there is a lack of public participation in scientific research ("citizen science")

around the TMDL (Aceves-Bueno et al., 2015). A citizen-science model would directly involve stakeholders in programmatic design and implementation, providing new knowledge or environmental stewardship (ibid). Second, a lack of transparency and information sharing between watershed managers and stakeholders presents barrier to successful management (Aceves-Bueno et al., 2015). Third, communication gaps result from the lack of commitment from interstate bodies on the Bay watershed. Fourth, the importance of both tidal and non-tidal states' effects on the Chesapeake Bay has not been stressed sufficiently. In order to create an operative, open dialogue, an understanding of the TMDL's shortcomings and contributions to the Bay is necessary.

Our democracy dictates that law and policy play a role in formal and informal governance. The manner in which authority is distributed among federal, state, and local authorities is the foundation of our federalist system of government. Agencies often need legal and organizational commitment to engage in self-governing activities or to contribute to joint governance processes (DeCaro et al., 2017). Agencies such as the EPA can inhibit adaptation in light of their unsupportive legal frameworks; this includes discouraging stakeholder self-governance. With the Chesapeake Bay TMDL, the EPA has authority to hold states accountable for their actions; but the EPA's political will to act on its authority is questionable in administering consequences for states' failure to meet TMDL goals.

At the same time, state and local governments must also remain cognizant of their respective roles in implementation. It is critical that centers of authority at the federal and state levels continue to create regulatory frameworks which enhance the ability, authority, and resources of stakeholders (DeCaro et al., 2017). Implementing

policies at the scale nearest the resource nested in federal oversight and assistance can enhance adaptive capacity and implementation (Cosens et al., 2017).

The TMDL helps the Chesapeake Bay watershed managers achieve their goals by promoting a collaborative working relationship between the federal, state, and local governments, and stakeholders. The Bay TMDL has been created in a manner that allows states to incrementally work toward achievable goals in pursuit of a larger, overall target. The accountability framework established by the Chesapeake Bay Program has been useful for states to assess their progress and report back to the EPA.

Adaptive Management Used in Implementation

The second theme stemming from this research involves adaptive management used within the implementation of the Bay TMDL. This theme was derived from the researcher's underlying questions as to whether adaptive management is used as a strategy in the implementation of the Bay TMDL, as well as whether adaptive management elements are evident in the implementation. The researcher assessed various definitions of adaptive management. Based on this assessment, the most refined and pertinent is Lyons et al (2008) and Doremus (2010): a way to address uncertainty, facilitating an open perspective for decision-making among water managers. There are seven objects identified by Lyons et al (2008) and Doremus (2010), which must be achieved for adaptive management to be successful. They are: monitoring data & collection, monitoring costs, accommodation to spatial & temporal scales, community involvement, engagement facilitation, and accountability.

Interviewees generally demonstrated a superficial familiarity of adaptive management when asked to define it. They were able to provide only a few examples of how adaptive management is applied to the Bay TMDL. For instance, multiple

interviewees recognized that two-year milestones are used as an approach to adaptive management – a way to assess progress in meeting the TMDL targets, and a way in which managers are able to make course corrections based on that progress every two years. A few interviewees recognized the importance of using adaptive management with the changing environment.

However, not one of the 18 interviewees administering TMDL implementation provided any context for stakeholder involvement or engagement. This is a major concern because stakeholders are the focal point in adaptively managing natural resources; the lack of stakeholders' ability to deeply understand the way adaptive management is used should be addressed. For instance, many interviewees from Pennsylvania – at the federal, state, and local levels – were not able to provide examples of adaptive management, and in some instances were not even generally familiar with the term. This poses great concern because adaptive management requires that interstate and intrastate bodies work collaboratively in achieving goals, especially when dealing with uncertainty (Doremus, 2010). Emerging adaptive management approaches that fit the complexity and integrated character of problems actively involve communities and stakeholders, as well as all types of knowledge to inform decision-making (Lemos, 2014).

This connects back to TMDL implementation effectiveness because interpretations of modeling and monitoring are difficult to understand. Further, Doremus (2010) emphasized the importance of modeling and monitoring for data evaluation in adaptive management. She further added that resources are not useful for adaptively managing unless they produce valuable information. Knowledge gaps can greatly undermine confidence and success in management decisions because actions

taken under uncertainty can move the system away from established goals. (Doremus, 2010; Lemos, 2014). The misunderstanding of adaptive management creates concern under conditions of uncertainty, particularly in an era of climate change.

Given gaps in understanding of adaptive management by Pennsylvanians, there is room for much improvement. One way to improve would be for stakeholders, across all levels to organize into groups such as the CBF, or social networks that work on improving WQs. These groups would have the ability to influence laws, regulatory systems, and rules to foster solutions to the social-ecological dilemma posed by nutrient loading from nonpoint sources (Ostrom, 2004; McGinnis & Ostrom, 2014). Governmental authorities have a role as well—that is, to develop strategies to motivate stakeholders to help resolve water quality concerns to the extent that they are formally vested with the responsibility or perceive themselves as having a stake (Ostrom, 2004).

Watershed managers do recognize the presence of adaptive management in the implementation of the Bay TMDL; but they do not fully understand its concept. In particular, watershed managers need a better understanding of adaptive management's components and how it is supposed to work in implementation, and then inform stakeholder communities of its application. Adaptive management requires a balance between short-term management objectives and long-term learning, as well as the devotion of resources to management and monitoring (Doremus, 2010; Cosens et al., 2017).

In sum, the Bay TMDL is an example of adaptive management to an extent, with watershed managers within agencies and organizations utilizing its processes to learn and reassess progress toward outcomes based on data. However, they are

missing an integral part—the communication piece for stakeholders. Stakeholders should engage in TMDL implementation because, ultimately, they are most affected by the changes.

Collaboration & Engagement

The third theme – collaboration and engagement – was developed from interview discussions. Successful changes must come from crafting policies that are aligned with the perspectives and understanding of those who are being affected. During interview discussions, interviewees claimed that collaboration is the most difficult aspect of TMDL implementation. In particular, because there are seven jurisdictions on the Bay watershed, effective communication is difficult. There is a defined scope of communication among all jurisdictions on the Bay watershed through workgroup meetings, alliance meetings, conference calls, etc. However, there are different perceptions and understandings, making it difficult for respective jurisdictional representatives to effectuate changes within their states.

Intergovernmental relations were recognized as a subtheme during the analysis process, with many associated challenges. As mentioned in the previous two themes, there is challenge in understanding the EPA’s role over the states of the Chesapeake Bay watershed. The relationship between knowledge and water management is never straightforward (Lemos, 2014). Further, all levels of government administrators must manage with a sense of adaptability. Some interviewees admitted that regulators did not always possess the willingness to change course and acknowledge new information. However, there has been evidence of improvement and it continues to be a work in progress. Additionally, it is noteworthy that tension between the federal

level and state level of governance is important because it forces a cooperative relationship in pursuit of a meeting of the minds.

There is a need for building greater trust between stakeholders and managers and enhancing the perceptions of managerial legitimacy in the adaptive management approach. The relationship between the two constituencies is never simple; however, it can be shaped by cultural, political, and institutional factors that foster scientific and social forms of knowledge (Lemos, 2014). It was recognized from interviewees that there is need to create more meaningful engagement, as it is critical that those with authority take advantage of the ability to integrate across the social and ecological knowledge base, and provide public and private stakeholders the information to implement rational environmental policy (Lemos, 2014). Scientific knowledge provided to those involved or affected is likely to build adaptive capacity and improve the effectiveness of implementation (Lemos, 2014). In fact, understanding what is needed to encourage the participation of citizen scientists is critical to integrating citizen science into management (Aceves-Bueno et al., 2015). In particular to the TMDL, incentives and motivation need to be an integral part of the program (ibid). Sense of place can act as a motivator when citizen scientists feel culturally connected to the place in which they work or live (ibid). Aceves-Bueno et al (2015) finds that citizen science can address the problem of poor stakeholder engagement in management by using sense of place, technology, and action to encourage participants' involvement. Thus, watershed managers should use citizen science as a way to engage stakeholders in management. At the same time, local stakeholders must be willing to cooperate in return. This often happens with effective dialogue between government and nonprofit organizational counterparties (Margerum & Robinson,

2015). Small communities, such as those surrounding the Chesapeake Bay, need to take the initiative in establishing and implementing TMDL plans. Ultimately, stakeholders and communities must take initiative to become engaged to inform decision-making (Lemos, 2014).

The possibility that public oversight may be inhibiting successful management needs to be addressed. How can watershed managers affect comfortable change while maintaining consistent, stable, and predictable implementation? This was repeatedly evident in responses from those in Pennsylvania who admit that many Pennsylvania stakeholders do not understand their impact on the Bay because it is a non-tidal state. Thus, the willingness to partake in implementation is lacking. Another reason behind unwillingness is evident in the agricultural community. Farmers admitted they do not practice implementing the Bay TMDL because they are not incentivized to do so. Under the Department of Agriculture is the Conservation Stewardship Program (CSP) for agricultural communities. CSP's provide incentives for farmers to undertake BMPs on their farms; if this initiative is presented with the TMDL program, farmers may be more inclined to adopt such practices. A way to address this is to decipher the message in a way that shows farmers they are being directly affected by their lack of involvement.

In addition, there is obviously a collective action problem with local communities in achieving the Bay TMDL. Collective action occurs when a number of individuals need to work together to achieve some common objective (Ostrom, 2004; Vanni, 2014). As proposed by Davis et al (2004), there are two different approaches to addressing collective action problems: cooperation collective action and coordination collective action. Cooperation collective action is a bottom-up approach, involving

farmer-to-farmer action, sometimes receiving support from governmental entities; whereas, coordination collective action is a top-down approach, promoted by government officials, without provision of support.

Yet even then, collective action problems present many challenges. People often fail to work together to achieve the same goal or common good (Ostrom, 2004). Ultimately, the solution is finding mutually beneficial ways of getting things done (Ostrom, 2004). Sometimes individuals are typically better off in the short run by choosing not to cooperate with others. For example, when individuals in the ag community of the Chesapeake Bay seek out short-term benefits for themselves alone, they are better off when others contribute to the collective action and they do not (Ostrom, 2004). To address this concern, watershed managers should ensure trust and legitimacy in relationships with stakeholders; and stakeholders should ensure stable relationships among one another.

Essential to the TMDL plan is organizing ways to inform others of the plan and its implementation. This has been difficult for the Bay watershed because implementing TMDLs requires the attention and views of not only local and state governments, but more importantly, all stakeholders on the watershed. Vesting stakeholders with responsibilities essentially alters the power dynamics and relationships, which in turn, creates encouragement and coordination, to diffuse conflict (DeCaro et al., 2017). Linking watershed managers and stakeholders with local knowledge and experiences creates an effective approach to achieving goals (Vanni, 2014); and educating stakeholders in a way that is understandable, accessible, and informative serves to empower them for successful participation in decision-making.

Maryland & Pennsylvania

There are clear differences between Maryland and Pennsylvania regarding the implementation of the Bay TMDL. Although there is room for improvement, Maryland has rightfully been recognized for its exemplary efforts in restoring the Chesapeake Bay watershed. Many participants interviewed from Maryland have a better sense of adaptive management and the context in which it should be used with the TMDL than those in Pennsylvania. Maryland is also focused on attempting to reach consensus among jurisdictions within the state while Pennsylvania is not. Further, Maryland has positioned itself better by being involved and engaged with local watershed managers, as well as local communities.

Pennsylvania has much room for improvement. Throughout the semi-structured interviews it was clear that Pennsylvania managers have an extremely poor understanding of adaptive management and its use in the implementation of the Bay TMDL. At the same time, many interviewees recognize that the failure to meet the TMDL target for the Bay is a direct result of Pennsylvania's implementation. The large geographic size and the unwieldy decentralized structure – there are 2500 municipalities, each with its own representative – renders communication and coordination problematic. An interviewee, a local representative of a county in Pennsylvania, claimed, “Some municipalities don't really have a good relationship with their neighbors.”

There also are large knowledge gaps in Pennsylvania. Many people do not understand their influence and the effects their activities have on the Chesapeake Bay watershed. An interviewee suggested that media coverage of routine community governance meetings would provide a no-cost medium for dissemination of essential

water quality management information. Consistent messaging to encourage constituents to take ownership and responsibility would be valuable.

Additionally, Pennsylvania managers must be willing to collaborate with other jurisdictions. It is understandable that inputs from each state are different (i.e., point sources, nonpoint sources), but the TMDL is a collective endeavor, which must be implemented in a way in which all states are pursuing common objectives.

Chapter 5

RECOMMENDATIONS & CONCLUSION

Building on the evaluation by Friesner (2015) on adaptive management used in local implementation of the Bay TMDL, I was able to identify similar findings and conclusions as well as additional findings and conclusions.

Both quantitative and qualitative data analysis in my study underscore areas where effectiveness in the current implementation of the Bay TMDL is lacking and could be enhanced. In particular, quantitative data suggests that Pennsylvania's performance is falling short of targets. Semi-structured interview results present a lack of understanding of adaptive management and its use in the implementation of the Bay TMDL. Further, research should be conducted amongst water managers to more accurately gauge perception and understanding of adaptive management and the extent to which it is being used within the implementation of the TMDL.

Federal and state governments must exercise their authority, but also provide for local government flexibility. Moreover, resources should be dedicated to improve knowledge among Pennsylvania localities on their impact on the Bay watershed and the importance of diligent participation in Chesapeake Bay restoration efforts. More importantly, the EPA should vest and promote the responsibility of state and local governance, as it enables trust and productive relationships, and maintains effective dialogue among self-interested actors (DeCaro et al., 2017).

The results here follow Friesner (2015), where he found that state and local governments ought to place greater emphasis on the local benefits of restoring the Bay

watershed, especially in the non-tidal areas. Building trust and legitimacy can be challenging and can take time as it is shaped by cultural, political, and institutional factors. Specifically, non-tidal states on the Bay watershed do not appear fully aware of their contribution to Bay water quality. Watershed managers have the legal authority to experiment and build the capacity of local communities to participate in developing solutions to this complex water issue (Cosens et al., 2017).

It would be useful for federal and state governments to provide support for cooperation in intergovernmental relations. Friesner (2015) also found a lack of cooperation between federal, state, and local levels of government. He noted that localities do not have the funding or resources to support TMDL implementation. Thus, with cooperation must come support at all levels – if federal and state governments expect implementation at the local level, they must be willing to provide some type of support while doing so.

One of environmental law's primary roles is to establish rules for society, instilling a sense of sustainability, stability and security, which in turn, enables stakeholders to contribute to the task of solving complex water issues, and plan for the future (DeCaro et al., 2017). The CWA establishes standards to restore and maintain clean and healthy waters. Further, the CWA gives EPA authority to implement pollution controls. The EPA is acting in its regulatory role as well as a part of the Chesapeake Bay Partnership. Acting in both roles may be confusing to state and local governments, but particularly to local governments. EPA should stand behind their administrative and technical duties to support states in their implementation and should remind jurisdictions of their stake in the TMDL. State and local governments

should be reminded of the accountability framework should their implementation measures not meet healthy water quality standards.

For instance, nonpoint sources should be regulated by states to improve water quality in the Bay. The enforcement must come from both EPA and states. In essence, if localities lack funding or technical capacity to implement TMDLs and improve water quality, the EPA should act in its partnership role to support those who are falling behind (Friesner, 2015). States and the EPA agreed to clean up the Bay watershed; therefore, they must pursue means to reach the agreed targets. However, EPA cannot force states to adopt and implement nonpoint source controls on agricultural pollutants; so it must come from the willingness of and collaboration among stakeholders to implement them.

Adaptive management is useful in complex environmental issues – it allows water managers to reflect, learn, and change tactics to remain consistent with goals and objectives. Though there are many definitions, Lyons (2008) and Doremus (2010) more recently suggest a working definition that includes a way to address uncertainty by facilitating an open perspective for decision-making among managers. It often emerges from creative processes initiated by imperiled environmental stakeholders – ranging from government agencies and officials, to members of the public, tribal nations and grassroots organizations (DeCaro et al., 2017). It also is an effective strategic initiative under uncertainty, such as climate change.

In addition to Friesner (2015) observations, the National Academy of Sciences (2011) and Scanlan (2013) observed that the Bay TMDL plan and the Watershed Implementation Plans (WIPs) incorporated into the plan suggest a lack of clear understanding of adaptive management. In order to meet objectives of adaptive

management, the authors suggested that the Bay and its jurisdictions fully analyze uncertainties relevant to decision-making, and monitor any efforts by states within the watershed to ensure full support from the federal level. The examples within this study suggest failure to fully recognize adaptive management.

Maryland stakeholders have a greater understanding of adaptive management than those of Pennsylvania. Similarly, Friesner (2015) noted that Maryland has positioned itself better by knowing and involving itself with local officials and local watershed managers of the Bay TMDL implementation, as opposed to Virginia; but there remains room for improvement for Maryland. Watershed managers should acquire expertise in adaptive management and welcome the participation of local stakeholders and communities. Their understanding that local communities are critical to decision-making was not apparent in the results of this study. Watershed managers have the responsibility to engage and support local communities, instilling reminders to the public that they also have authority to inform decision-making (Lemos, 2014; DeCaro et al., 2017). In order for goals and outcomes to be achievable and effective, it is essential that adaptive management practices on the Chesapeake Bay include more effective communication to stakeholders and community members. Consistent with the findings here and in Friesner (2015), private, state, and federal entities need to step up and provide stakeholder engagement and involvement to create a genuinely adaptive management approach to implementing the Chesapeake Bay TMDL at the local level. At the same time, local governments must receive guidance and support from state and federal agencies.

Managers should be able to present a logical argument for how and why a particular program can address a specific problem; they should also be able to explain

how measurement and evaluation will assess and improve program effectiveness (Newcomer et al., 2015). Managers do not always have clear and consistent answers to problems, but program evaluation is a logical place to begin to seek answers. There are obvious differences in the way states implement the Bay TMDL. As noted in Friesner (2015), the structure of implementation may explain the reason behind the lack of cooperation between states.

There should be a consensus and clear understanding of what exactly adaptive management means to those involved in the Chesapeake Bay watershed. This is essential to solicitous decision-making. Research should be undertaken following the Phase III WIP to decipher whether there is improvement on the engagement of stakeholders. Also, it is necessary to further understand any constraints within the federal and state levels of government causing lack of effectiveness. The Chesapeake Bay may benefit from the application of adaptive management strategies, including integrative, flexible and responsive management policies. Adaptive management strategies and practices are the key to addressing those uncertainties posed by the inefficiencies of current Bay water quality strategies.

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Appendix A
IRB LETTER

	RESEARCH OFFICE	210 HULLIBAN HALL UNIVERSITY OF DELAWARE NEWARK, DELAWARE 19716-1551 PH: 302/831-2136 FAX: 302/831-2828
DATE:	November 7, 2017	
TO:	Alexis Cunningham, MS	
FROM:	University of Delaware IRB	
STUDY TITLE:	[1148827-1] Adaptive Management Strategies on the Chesapeake Bay Regarding TMDLs	
SUBMISSION TYPE:	New Project	
ACTION:	DETERMINATION OF EXEMPT STATUS	
DECISION DATE:	November 7, 2017	
REVIEW CATEGORY:	Exemption category # (2)	
<p>Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.</p> <p>We will put a copy of this correspondence on file in our office. Please remember to notify us if you make any substantial changes to the project.</p> <p>If you have any questions, please contact Nicole Farnese-McFarlane at (302) 831-1119 or nicoletm@udel.edu. Please include your study title and reference number in all correspondence with this office.</p>		
- 1 -		
<small>Generated on IRBNet</small>		

Appendix B

INTERVIEW PROTOCOL

Instructions (Chesapeake Bay): Good afternoon. My name is Alexis Cunningham and I am a Master's degree candidate in Water Science and Policy at the University of Delaware. I am conducting research on the Chesapeake Bay for my thesis research project. The questions for this project will focus more specifically on implementation of the Bay TMDL using adaptive management. Further, perceptions and knowledge of key constituents will be measured in order to understand the efficacy of TMDL implementation and the practice of adaptive management as a method of the TMDL implementation.

Tape recorder instructions: If it okay with you, I will be using a tape recorder to adequately capture pertinent answers to the questions I plan to ask you during this time. If you are comfortable with this process, I ask that you orally confirm or sign the consent form, as appropriate, on the use of this project, that way in which your confidentiality will be maintained, and your understanding that the recordings will be deleted within three years of the thesis being accepted to allow for a period of time to publish the results in a peer review journal.

Interview questions:

The following questions will be asked during the interview process:

BACKGROUND / DEMOGRAPHICS

1. Briefly, tell me about your background
 - a. What is your role in the program [office, community]?
 - b. How long have you worked in this position?
 - i. Part-time/ full-time?
 - c. What did you do before?
 - d. Education

QUESTIONS

1. What does adaptive management mean to you?
2. Can you provide some examples of adaptive management you have seen on the Chesapeake Bay?
3. Is adaptive management used with the implementation of the Bay TMDL?
4. How were water quality efforts working before the TMDL was introduced?
5. Are you finding any concerns or issues with the Bay TMDL?
6. Can you describe how stakeholders are involved in the TMDL process?
7. Do you think the TMDL should be implemented differently?
8. What are the strengths and weaknesses of the Bay TMDL?
9. How does your program [office or community] assess the effectiveness of the Bay TMDL?
10. Is there anything else you would like to add? Anything interesting I should know about TMDLs or adaptive management?

Appendix C

INTERVIEW RECRUITMENT LETTER

Dear [subject's name],

Hello, my name is Alexis Cunningham. I am a graduate student at the University of Delaware in the Water, Science and Policy Program. I am conducting research on adaptive strategies for the Chesapeake Bay watershed total maximum daily Load (TMDL) plan for my master's thesis.

As a major participant/stakeholder in [state's] in the implementation of the Bay TMDL your role as [title] at [organization] OR as a farmer OR for the state of [state], your insights and viewpoints would be of great help to us in this master's research.

I am reaching out to people who play an important role in Bay TMDL implementation in order to understand how the TMDL program is working and what role adaptive management plays in its success or failure.

I am thus writing to ask if you would agree to be interviewed for about 30 minutes? It would mean a lot if I could include your views in the study.

I can give you a call later this week to set up a time that's convenient for you.

I look forward to your response.

Sincerely,

Alexis Cunningham
aerin@udel.edu

Appendix D

INFORMED CONSENT LETTER

Thank you for agreeing to be interviewed as part of the above research project. Ethical procedures for academic research undertaken from the University of Delaware require that interviewees explicitly agree to being interviewed and how the information contained in their interview will be used. This consent form is necessary for us to ensure that you understand the purpose of your involvement and that you agree to the conditions of your participation.

I agree to participate in the interview process designed to understand adaptive management with the Chesapeake Bay TMDL plan. Alexis Cunningham is conducting this interview for her Master's research through the University of Delaware. During the interview, there will be program evaluation questions on the TMDL plan and program initiatives as well as program objectives, priorities and practices.

Alexis Cunningham has explained to me how this interview is related to the goals of the thesis research and project. I understand I was selected based on the relationship between my organizational roles or responsibility and the TMDL plan. My participation in this project will help the interviewer as a part of her research.

I understand that this interview will be tape-recorded. The interviewer will maintain confidentiality of any personally identifying information obtained during the course of the interview, unless I give the interviewer permission to use any or all of the information in her thesis paper and/or in a peer review publication or report. If permission is granted, the interviewer may or may not choose to use the information in her thesis paper. I also understand that the tapes being used and recorded during the interview process will be archived once they are transcribed.

Please initial below and indicate whether or not you give the interviewer permission to use the following identifying information when referring to a quote or phrase given to the interviewer during the interview.

_____ YES, I agree. The interviewer may use the following information as marked below: (Please check all that you consent to.)

_____ Your name _____ Your professional title

_____ Your organization

_____ NO, the researcher may not use any personally identifiable information.

Once the information is no longer needed for this study or thesis, then all personally identifiable information will be removed from the interview contents and the information will be archived. All the information will be deleted from any other device (such as flash drives or audio recorders) in order to maintain the highest level of confidentiality possible. Because of these measures to ensure confidentiality, I understand that there is minimal risk to me. I understand that my participation in this study is voluntary and without compensation and that I may refuse to answer any specific questions raised during the interview process. If I wish to withdraw from the study, I may do so at any time without giving any reason or explanation for doing so. If I choose to withdraw from the study, I understand that this will have no impact on the organization in which I am involved.

The interviewer has answered all the questions that I have about the study and what is expected of me. I understand that if I have any questions after the completion of the interview, I may contact the researcher, Alexis Cunningham by email at arin@udel.edu.

If you wish to ask questions about the interview, the study, or anything else related to your participation in this study, please contact the researcher's thesis advisor, Dr. Jeremy Firestone by phone at 302-831-0228 or by email at jf@udel.edu. If you have questions about your rights as a participant in this research project and do not wish to contact the interviewer, you should contact the Institutional Review Board at the University of Delaware by phone at 302-831-2137.

1. I agree to be interviewed for the purposes of the research project: Adaptive Strategies for the Chesapeake Bay Regarding TMDLs
2. The purpose and nature of the interview has been explained to me, and I have read the consent form as provided by the interviewer.
3. I agree that the interview may be tape-recorded.

4. Any questions that I asked about the purpose and nature of the interview and assignment have been answered to my satisfaction.
5. I understand that my participation in this project is voluntary, and I understand the interviewer will maintain confidentiality of any personal information.

I have read and understood the information above, and I agree to participate.

Name (please print)

Date

Signature

In addition to agreeing to participate, I also consent to having the interview tape-recorded.

Signature

Date