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# Analysis of Managerial Decision-Making within Florida's Total Maximum Daily Load Program

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Analysis of Managerial Decision-Making  
within Florida's Total Maximum Daily Load Program

by

Justin Barthle

A thesis submitted in partial fulfillment  
of the requirements for the degree of  
Master of Science of Environmental Science and Policy  
Department of Geosciences  
College of Arts and Sciences  
University of South Florida

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Analysis

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## DEDICATION

I dedicate this Thesis to my family who have always shown me love, patience and have molded my perseverance. Their continued support lifts me higher than I could go on my own.

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## LIST OF ACRONYMS

WQM	Water Quality Managers
TMDL	Total Maximum Daily Load
EPA	Environmental Protection Agency
FDEP	Florida Department of Environmental Protection
CWA	Clean Water Act
RI	Random Index
GCI	Geometric Consistency Index
CR	Consistency Ratio
WQS	Water Quality Standards
IRB	Institutional Review Board
AM	Adaptive Management
AHP	Analytical Hierarchy Principle
MCDA	Multiple Criteria Decision Analysis
IWR	Impaired Water Rule
BMAP	Basin Management Action Plan
BMP	Basin Management Plan
FWRA	Florida Watershed Restoration Act
GAO	Government Accountability Office
GIS	Geographical Information Systems
BASINS	Better Assessment Science Integrating Point and Nonpoint Sources

## ABSTRACT

Water quality has evolved legislatively from protection of navigation routes and quantity of sources to more emphasis on impairments on water quality for surface and groundwater sources. Nonpoint or diffuse sources of impairments represents a major challenge for management due to the complexity of its sources and difficulty in tracking.

The most cited sections on public policy analysis focuses on the overall process agencies employ to understand the results the program yields. Often overlooked are finer details and mechanisms, such as decision-making and priority setting, which have a great impact on the overall process. To investigate these factors, we need to analyze the decision-making process used by managers.

This study focuses on using information from those with direct involvement in the establishment and implementation of the Total Maximum Daily Load program for the state of Florida. This study used decision-making analysis models from Rational-Decision-Making and Multi-Criteria Decision Analysis concepts to construct questionnaires that looks to develop priorities as seen by managers' preferences for several presented options. This methodology allowed us to structure the viewpoints and processes water quality managers use to breakdown decisions.

The analyzed results show water quality managers prefer strong management options, involvement from stakeholders with scientific knowledge, and data collected from the source or point of impact. Interestingly, opinions in the group show that urban best management

practices are considered more effective than their agriculture counterparts with a disfavor for volunteer derived data.

Ultimately, the survey highlights the need for more robust enforcement and reliable measurement of non-point source of impairments. Continued public outreach and education, especially through workshops, are denoted as important tasks to completing successful TMDLs and should be expanded and strengthened by both the Florida Department of Environmental Protection and its boundary programs.

## **CHAPTER 1:**

### **INTRODUCTION**

With water being essential for life, the importance of maintaining quality, both for human consumption and ecological purposes, has become a critical point in the past few decades. In response to these priorities, protection of water resources has evolved dramatically, altering its intent from navigability to protection of quantity and quality for human and ecosystem functions (Migliaccio, Li, & Obreza, 2007).

With expanding populations, sources of potential impairments have multiplied. Societal needs place demands on natural systems that are often beyond the capabilities of natural processes. Further exacerbating this are the effects of anthropogenic pollutants on ecosystem quality and the negative feedback they create with degradation. From rivers overflowed with waste (Alder, 2002) to the anthropogenic eutrophication of aquatic and marine ecosystems (Smith, Tilman, & Nekola, 1999), water quality has been severely degraded due human population expansion. Managing water quality requires a multifaceted effort that connects stakeholders to current and continuous data monitoring and flexible management strategies that protect and improve water quality.

As advancements in GIS (Tim, Mostaghimi, & Shanholtz, 1992) and computer modeling (Santhi, Arnold, Williams, Hauck, & Dugas, 2001; Moore & Vasconcelos, 2016) continue to develop, watershed managers can identify the origination and fate of potential pollutants. In addition, the development of isotopic analysis of non-point sources of pollution,

while constrained (Mayer, et al., 2002), has shown the ability to aid in source determination and tracking (Mitchell, Babcock, Gelinas, Nanus, & Stansey, 2003; Reed, Wang & Duranceau, 2016).

With the input of these tools and reliable monitoring, managers can implement total maximum daily loads (TMDLs) to protect and improve the water quality for the water bodies they supervise. As a policy, the Total Maximum Daily Load (TMDL) program was devised as part of the Clean Water Act (CWA) to enforce and regulate point and non-point sources of pollution into water bodies. At the start of the TMDL program, problems with enforcement and planning existed, which led to a program revision in the early 2000s. TMDLs were adapted with state requirements for deadlines, water body listing and public involvement to ensure efficient and successful management of quality problems. Even with its revisions, the program still suffers questions of effectiveness and difficulties in implementation (Houck, 2002).

To improve implementation, the Federal and State levels of TMDL implementation agencies have sought to streamline the process to maximize results and reduce variances. By disseminating methodologies and technological advancements that prove successful, agencies ensure information availability strengthens the program (Whittemore & Beebe, 2000). States maintain the institutional authority to construct a program off the federal guidelines so some differences still exist in success rates on a state-by-state level in addition to discordances on a case basis.

The majority of public policy work focuses on the process or broad legal mechanisms in an effort to understand the results of a particular program. Studies often overlook the finer details and mechanisms, such as decision-making and priority setting, which can have a great effect on the process. Here, we can decipher information that will produce insight about the process that can ultimately be used to create a stronger process tailored to the inputs of those

who manage the program. To investigate these factors, we need to analyze the decision-making used by managers. This study focuses on these factors using information from those with direct involvement in the establishment and implementation of these programs: water quality managers (WQMs).

To complete an assessment of the TMDL program for the Florida, we used decision-making analysis models from Rational-Decision-Making and Multi-Criteria Decision Analysis concepts to construct a questionnaire to gauge WQMs' viewpoints on the development and implementation process for TMDLs. We then administered a survey using this questionnaire with the cooperation of WQMs from various counties in Florida that had experience working on TMDL projects. This methodology allowed us to structure the viewpoints and processes WQMs use to breakdown decisions and create meaningful insights on how information is perceived and the priorities taken during the TMDL process. In addition, we synthesized common problems and recommended possible improvements for the program based on the survey responses.

The remainder of this paper is set out as follows. Chapter 2 provides a literature review explaining the process and evolution of both the national and Florida's TMDL program, identifying areas researched related to TMDL implementation analysis and its criticisms. Chapter 3 covers the methods of decision making and program management analysis related to this proposed study and forms the conceptual framework used to create the methodology employed. Chapter 4 outlines the study research design, detailing the research questions, hypotheses and their relative significance. Chapter 5 details the methodology used to complete the study Chapter 6 describes the study area and the demographics encountered. Chapter 7 reviews the collected results of the research from the survey, and Chapter 8 discusses the elements of significance found during the study and the limitations faced during the review. Finally, Chapter 9 summarizes and concludes the thesis.

## **CHAPTER 2:**

### **LITERATURE REVIEW**

The Literature Review is divided into 3 sections. The first reviews the National Total Maximum Daily Load Program, its inception, litigation history and critiques. The next section covers Florida's program and its legislative history and development. The final section compares the two and highlights differences compared to other state TMDL programs.

#### **2.1: National Total Maximum Daily Load Program**

Emphasis on water quality heightened in the 1960s when pollution in the Cuyahoga River in Cleveland, Ohio caught fire (Houck, 2002). Subsequent reports that accessed 1/3 of the nation's water systems did not meet water quality criteria, which prompted Congress to implement a new pollution control measures (Houck, 2002). In the 1970s, the federal government passed amendments to the Federal Water Pollution Control Act aimed at protecting the quality of water resources and meeting prescribed standards. These amendments, referred to as the Clean Water Act (CWA), set federal necessities for identifying polluted water bodies (Migliaccio, Li, & Obreza, 2007). The CWA also developed a method for estimating loads of a pollutant that could be received by a water body and still meet quality standards. This model is referred to as TMDL or noted as section 303(d) of the CWA (Migliaccio, Li, & Obreza, 2007). Water quality standards are based on



the designated uses of a water body and the numerical and non-numerical criteria needed to sustain those uses (Houck, 2002).

According to the Environmental Protection Agency's (EPA) definition, TMDLs are "the sum of allocated loads of pollutants set at a level necessary to implement the applicable water quality standards, including: waste allocations from point sources and load allocations from non-point sources and natural background conditions. A TMDL must contain a margin of safety and a consideration to season variables" (US EPA, 2012). Another useful definition is considering TMDLs a mathematical equation: Amount of Impairment Allowed While still Meeting Water Quality Standards,  $TMDL = \sum WLA_i + \sum LA_i + MOS$  (Houck, 2002; EPA, 2012), where  $\Sigma$  = the summation,  $WLA_i$  = waste load allocations (point source),  $LA_i$  = waste load allocations (non-point) and  $MOS$  = margin of safety with inclusion of seasonal variance. A margin of safety is typically a subjective decision based on the relative significance of contributing sources. Most TMDL calculations use uncertainty analysis (Zhang & Yu, 2002)

Most states have lacked the assets to complete TMDL analyses and had limited baseline data to draw up TMDL development plans (Houck, 2002). The EPA was largely hesitant to interfere in the states' development plans and lacked resources to fully enforce implementation of TMDL programs, thus little implementation actually occurred until 1992 when the EPA mandated that states list waters that did not meet standards and repeat the process every two years. They required states design TMDLs to improve quality in those listed, as reported in the congressional report Clean Water Act and total maximum daily loads of pollutants (Copeland, 2003).

### **2.1.1: Process Overview**

TMDLs are a federal requirement within the CWA. States are mandated to provide the EPA information regarding water quality standards found in the state and projections to

improve quality in areas where degradation has inhibited meeting standards established by the EPA or state requirements, where applicable. The process is summarized by Maryland Department of Environment as the following (Maryland Department of Environment, 2012):

- 1) Establish Water Quality Standards (WQS)
- 2) Collect data
- 3) List water bodies that do not meet WQSs with aid from technology-based controls alone (303(d) list)
- 4) Set priorities for the water bodies listed
- 5) Establish TMDLs that aid in meeting WQS for each listed water body
- 6) Request public comment
- 7) Present 303(d) list and TMDLs to EPA for approval
- 8) Implement TMDLs and continue monitoring

Figure 1 highlights the cycle the TMDL process covers in an attempt to improve water quality (U.S. EPA, 1999). The process is renewed when a new impairment is discovered or water body is found in need of restoration. This equation is the backbone of the system; it considers the assimilative properties of the water body, estimation from all potential sources, a predictive/modeling solution to changes in pollutant load over time and a calculated margin of error to safely meet water quality standards. Once a TMDL is created for an impaired water body, an action plan must be developed to help meet reduction goals (U.S. EPA, 2012).

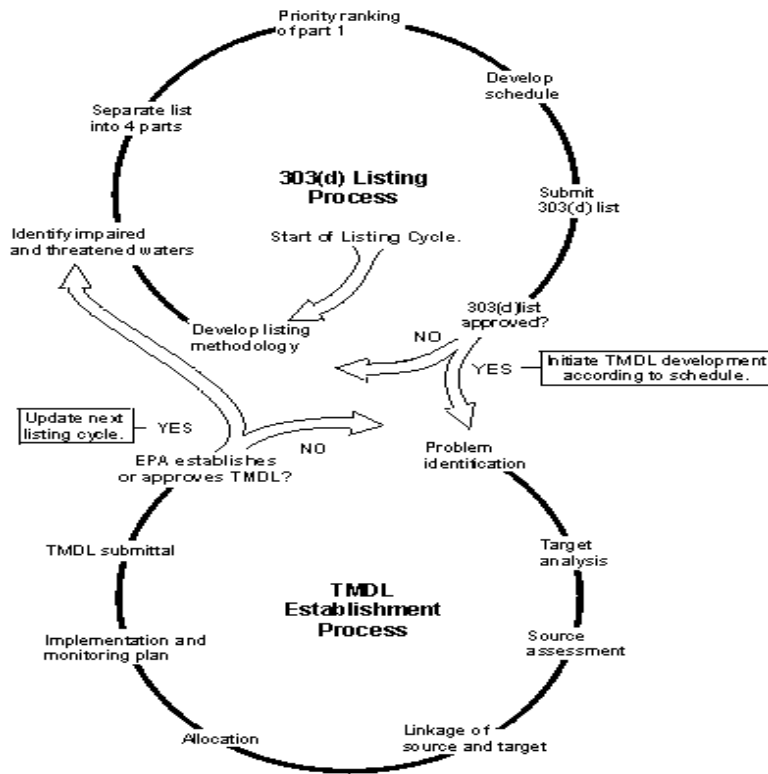


Figure 1: TMDL Process (U.S. EPA, 1999)

States are given leeway in the creation of action plans and TMDLs, but due to several factors, states have been reluctant to take charge of their programs. These factors will be discussed in detail in section 2.1.3 Criticisms regarding TMDL programs but include costs, science, data and enforcement measures. This required the EPA to alter the national program to step in and create requirements for all states and even the development of state plans to aid in TMDL development. The national program has a larger budget to draw from, so the EPA has developed a staff and tools to aid in state progression through the 303d program, including the creation of modeling software (BASINS) and methodologies for analyzing watersheds and creating TMDLs (Tim et al., 1992).

### 2.1.2: Legal Development

Responding to the breakdown of the states and the EPA to meet TMDL requirements, conservation groups filed 40 lawsuits in 38 states (U.S. EPA, 2009). Twenty-seven resulted in

court orders demanding quick development of TMDL programs either by state authorities or the EPA (U.S. EPA, 2009). The following five cases represent where significant litigation occurred and the litigation activities specified been met by the EPA (Harrigan-Lum & Lum, 2000):

- Sierra Club v. Hankinson, 939 F. Supp. 865 (D. Ga.1996) – mandated EPA to construct TMDLs based on excessively slow timeline implementation used by the state
- Alaska Center the Environment v. Reilly, 762 F.Supp. 1422, 1428-29 (D. Wash. 1991) – states that do not submit TMDLs in a timely manner run the risk of their water quality programs being taken over by the EPA and possibly put under a court ordered schedule
- Natural Resource Defense Council v. Fox, 909 F.Supp. 153, 158 (D. N.Y 1995) - rejected the EPA notion that EPA mandated TMDLs could only be used in instances that the state chose not to submit a program
- Idaho Sportsmen’s Coalition v. Browner, 951 F. Supp. 962, 965 (D. Wash. 1996) – rejected EPA’s claim it had no authority to develop state TMDL, cautioned that the TMDL process should take months to years, not decades
- Scott v. City of Hammond, Ind. 741 F.2d 992 (7<sup>th</sup> Cir. 1984) – held that the Clean Water Act requires the EPA to approve proposed TMDL no later than 30 days following submission. If disapproved or prolonged failure to submit, EPA allowed to construct TMDLs for state’s impaired water bodies, held that a state’s “lack of knowledge” was accommodated in the margin of error in TMDL formulation and could not be used as an argument against TMDL development

In 1999, the EPA proposed modifications to the TMDL regulations to help clarify and reinforce the program due to litigation brought on by these cases. Its key changes included: a requirement for a more inclusive list of impaired water bodies; a new requirement that states establish and submit schedules for forming TMDLs; a requirement for listing procedures to be more precise (subject to public view and to be submitted to the EPA); and clarification that TMDLs include the following 11 specific elements (Copeland, 2000a):

1. Water body name and location (WBID)
2. Identification of the pollutant and the water quality standard for which the TMDL is being developed
3. Calculation of the pollutant load that may be present in the water body but still meet standards
4. Calculation of the amount by which the current pollutant load differs from the quality standards
5. Identification of the sources for which the waste-load allocations and load allocations are being established
6. Waste load allocations for point sources
7. Load allocations for non-point sources, including atmospheric deposition, groundwater or natural background
8. Margin of safety
9. Seasonal deviations
10. Allowance for future loadings
11. Implementation strategy

States, industrial and agriculture sources opposed the new regulatory changes, feeling they unfairly burdened them (Reisch & van Heuven, 2001). This sparked congressional review and revisions leading to a final rule. In 2000, the EPA published the final rule built

upon the old TMDL program with added details, specific necessities and deadlines that obligated states to implement plans to improve water quality in impaired water bodies (Copeland, 2000b). It retained some of the basic elements of the first proposal, such as an inclusive identification of impaired waters, creation of schedules, specificities (those listed above) and public participation. It omitted some of the controversial elements, particularly the requirement of the permit system on agriculture and forestry operations (Copeland, 2000b). After a lengthy review by Congress and the Bush administration the final rule was implemented in April 2003 (DeBusk, 2001).

### **2.1.3: Criticisms Regarding TMDL Programs**

Several issues have plagued the TMDL program since its inception that have ultimately hampered and stalled implementation of the program. These complications include: lack of reliable and long-term data, issues with supporting science, costs and state enforcement (Houck, 2002). Some objections are legitimate concerns and present real problems to plan development and implementation. Inherent in regulatory criticism are the underlying motives of regulated parties, idealizing science in order to undermine or delay regulatory authority. These strategies include the manufacturing or magnifying uncertainty (Michaels & Monforten, 2005), demanding “sound science” or irrational standards of evidence (Neff & Goldman, 2005) and data quality initiatives that permit discrediting of studies by highlighting assumptions, funding and areas of additional research (Wagner, 2005; Caudill & Curley, 2009). The Association of Metropolitan Sewage Agencies published a guide that included challenging in court an impaired water listing by challenging for “sufficient reliable data” (Houck, 2002):

“The states and TMDL-implicated communities . . . are alert to . . . weaknesses in monitoring and assessment and have already signaled their willingness

to exploit them . . . Opposing listings as based on inadequate science (‘drive-by listings,’ in the words of one agriculture industry attorney—a characterization that in some cases may not be far from the truth), farm and other non-point interests have persuaded states to reduce their submissions on impaired waters to the absolutely proven, with significant results. Incongruous as it may seem in the face of new EPA listing criteria designed to be all inclusive, to err on the side of listing, and to facilitate the use of ‘all relevant data,’ many states have actually cut their 303(d) lists in half since 1996, relegating hundreds of waters to such categories as ‘further study,’ ‘insufficient information,’ and only ‘moderately impaired.’” (Houck, 2002)

Regardless, there are relevant concerns about the development and implementation of TMDLs for impaired water bodies that must be assessed and resolved in order to make applicable and effective TMDLs.

### **2.1.3.1: Data Availability**

Ambient-based water quality management (e.g. TMDLs) is severely challenged by demands for current, continuous and definitive data. In 2000, the Government Accountability Office (GAO) released a study detailing wide inconsistency and incomplete information on existing water quality. It also found that the majority of the nation’s waters remained unmonitored and unassessed (GAO, 2000). In 2001, state lists were assessed at 21,000 impaired waters requiring the need for 40,000 TMDL plans (National Research Council, 2001).

Water quality data is severely lacking nationally and locally; the process is largely dependent on the state, which must use appropriate training and methods in order to ascertain water quality monitoring protocols and reliable data. Public monitoring programs have been

steadily increasing, with support from the EPA (U.S EPA, 2012) in an effort to close the data and monitoring gap (Lunenburg, 2004).

The EPA produced a GIS based modeling system to aid state officials in developing TMDLs. This modeling program, known as BASINS, makes use of several government GIS databases to simulate pollutant flow through a watershed (Whittemore & Beebe, 2000). Studies have found that these records are incomplete or suffer from poor quality, resulting in erroneous analyses and calculations (USGS, 1998). Inaccuracies include: typos, unit errors, missing or truncated data or limit errors (NCASI, 1997). These inaccuracies can undermine TMDLs using this modeling system. The EPA data along with other government databases, have improved over the years, but data still remains an evolving issue (Glasgow, Burkholder, Reed, Lewitus, & Kleinman, 2004; GAO, 2013).

### **2.1.3.2: Scientific Background and Processes**

A common argument or accusation used by opponents to TMDL legislation centers on allegations that the science used in creating the TMDL is not strong or precise enough to prevent the listing of an impaired water body. States are not required to make a listing if evidence is inadequate (Caudill & Curley, 2009). If a TMDL is established, then more thorough arguments are needed, requiring more data, alternative procedures or models and uncertainty analyses to be considered to halt TMDL implementation (Caudill & Curley, 2009).

The Congress mandated study, performed by the National Academy of Sciences, found that while the science exists and its uncertainty can be reduced, its practice is faulty. From modeling, data collection, training or state capacity, the program lacked rigor and found that much of the program relied on static and insufficiently comprehensive data monitoring and modeling (Reckhow, et al., 2001).



The BASINS modeling program has been questioned for its validity in simulating point and non-point pollution movement through a watershed. The main argument consisting that the basic program BASINS is built off is a non-distributive model and is ill-equipped to handle the multiple variables present in water quality modeling. The model is not physically based, so while it can be calibrated, the parameters have vague real world links to natural variables (Whittemore & Ice, 2001). The software eases the burden of data entry on the technician but in doing so, creates poor understanding and increases the uncertainty regarding the development of the TMDL (Whittemore & Beebe, 2000). It has been suggested that modeling is over relied upon for environmental decision-making, and more monitoring programs are needed to restore good scientific principles (Glaze, 1998).

In addition, some stressors, such as nutrients and heavy metals, are measured in their totality rather than what is chemically or biologically available. This skews the data and alters the actual harm that an impairment load may have on a water body (Lee, 2001). Atmospheric deposition is not accounted for in TMDL planning, and its overall impact on water quality is questioned (Saltman, 2001). Keller and Cavallaro (2008) detailed examples of TMDLs that function with atmospheric deposition as a non-point source, stating that the EPA expects reductions to occur mainly through the Clean Air Act.

While recognizing lawmakers' concern over the "paucity of data and information available to the states ... [to] meet water quality standards," a committee appointed by the National Research Council concluded that "the data and science have progressed sufficiently over the past 35 years to support the nation's return to ambient-based water quality management" (National Research Council, 2001; Keplinger, 2003).

### **2.1.3.3: Economics and Associated Costs**

The EPA issued a draft report on the costs for developing and implementing the TMDL programs, estimating the average annual cost to the states to be \$63 -\$69 million for development and could be \$900 million to \$4.3 billion per year for implementation, depending on the state (Copeland, 2000c). These estimates are outdated and off by a wide margin, actual data points are hard to track down and early EPA estimates were based on 36,000 developed TMDLs rather than the 69,000 currently proposed (Owen, 2016)

The change from effluent standards to ambient regulation is undoubtedly costly with implementation costs, time, effort and expertise needed to conduct TMDL development. These difficulties and complexities are often cited as a top concern with the TMDL program (Hun, 1998). Reported studies conducted by the EPA have cited developmental costs ranging from \$4.036 to \$1,024,000 for individual TMDL programs (U.S. EPA, 1996). The same study found that data monitoring and modeling significantly contributed to the final expenses (Boyd, 2000).

Neither the estimation of costs or benefits is required to complete a TMDL program since they are purely based on ambient standards rather than economic. The National Research Council still recommends that both costs and benefits of various levels of water quality be evaluated and incorporated into the assignment of designated uses of water bodies and the TMDL development process (Keplinger, 2003; National Research Council, 2001). EPA requires states to create prioritized hierarchies (U.S. EPA, 2016) to properly organize implementation activities. Economic modeling and analysis have increased over the years aiding in development of cost effective and efficient TMDL plans (Bosch, Ogg, Osci, & Stoecker, 2006); in addition, states have begun constructing hierarchies to effectively and efficiently use state funds to complete TMDL projects.

#### **2.1.3.4: Enforcement Mechanisms**

In 2001, the EPA's Office of the Inspector General conducted an audit and found that state authorities enforced regulations and permits poorly (Houck, 2002). Finding that even in point source monitoring, which has permit-based numerical standards, only 10 states reported a 90% or better compliance rate. Twenty states did not even reach 75%. In the case of non-point violators, such as feedlots or urban runoff, permit systems were in place but even basic monitoring systems were not in place. The reasoning for some of this lack of enforcement is due to financial costs as well as a lack of will (political) to pinpoint violators (Office of the Inspector General, 2001).

Enforcement is left to the states' discretion in determining whether control efforts are voluntary or compelled, regulatory or non-regulatory. There is no explicit given authority to the Federal government regarding TMDLs (Houck, 2002; Boyd, 2000). The EPA can hold a state's permitting rights if there is a failure to comply as well as a restriction for federal grant money. Largely, states rely on voluntary, unenforceable measures to deal with non-point pollution, deferring to incentives, cost sharing and voluntary programs already in place (Environmental Law Institute, 1997).

Jurisdictional conflicts can hinder TMDL development as state and even county boundaries can present difficulties in policy implementation and cooperation (Houck, 2002). The CWA requires states to resolve disagreements with other jurisdictions during the TMDL process.

The EPA has included provisions detailing, "implementation plans contain reasonable assurances that implementation activities will occur" (Office of Water, EPA, 2000). These provisions require details for how monitoring will be implemented, what enforcement tools will be used and what funding will be made available. The more specific a TMDL plan is, the greater likelihood that load reductions are realized (Boyd, 2000). In May 2002, the Ninth

Circuit Court of Appeals ruled in the case *Pronsolino v. Nastro* that the TMDL provision of the CWA certified the EPA to list and develop a TMDL for the Garcia River in Northern California, based solely on non-point source pollution (Tobin, 2003). The decision was contentious since it established that sources of polluted runoff, such as logging, farming and grazing, might be held accountable under the CWA (Tobin, 2003).

## **2.2: Florida Total Maximum Daily Load Program**

To address the Federal TMDL program and its new requirements, the state of Florida passed the Florida Watershed Restoration Act (FWRA) in 1999 (Drew, 2005). This act specified methods for the Florida Department of Environmental Protection (FDEP) to follow in the creation and installation of TMDLs on impaired water bodies. The mandate for the program is enormous and complex, given the variety of hydrological systems present within the state (Drew, 2005).

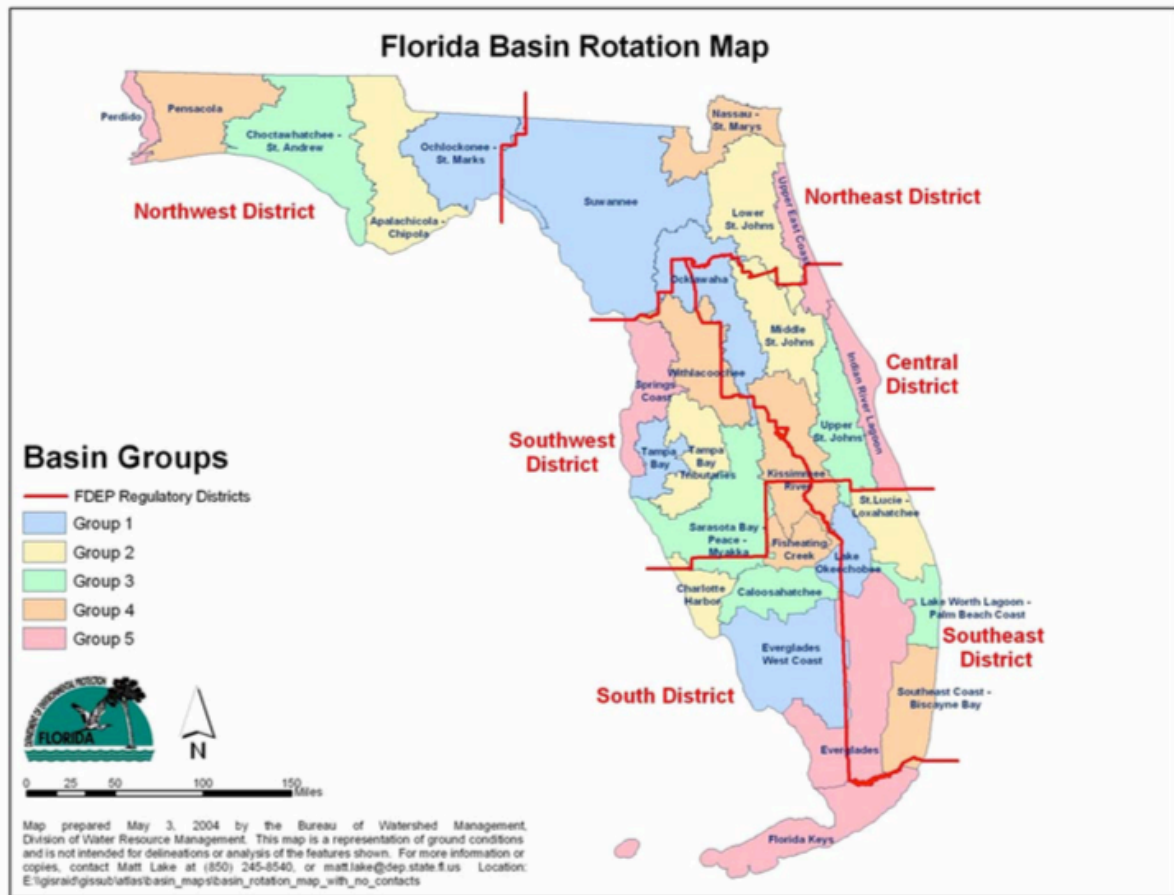
### **2.2.1: Development of Program**

To streamline the TMDL process, the FDEP has adopted a comprehensive “watershed management” strategy that divides the state into natural watershed boundaries rather than political boundaries. These watersheds are divided into five groups of basins (Figure 2). The FDEP addresses each basin individually and, over a five-year cycle, initiates activities in each one while continuing to assess and reevaluate the methods and data in those plans previously in place. Each basin undergoes a five step developmental phase (Migliaccio, Li, & Obreza, 2007):

- 1) Initial basin evaluation
- 2) Coordinated monitoring
- 3) Data examination and TMDL development

- 4) Basin Management Action Plan (BMAP) development
- 5) Implementation of basin management plan

This cycle repeats every five years until water quality standards are met and the water body is delisted.



DEP District	Group 1 Basins	Group 2 Basins	Group 3 Basins	Group 4 Basins	Group 5 Basins
NW	Ochlockonee-St. Marks	Apalachicola-Chipola	Choctawhatchee-St. Andrews Bay	Pensacola Bay	Perdido Bay
NE	Suwannee	Lower St. Johns	N/A	Nassau-St. Marys	Upper East Coast
Central	Ocklawaha	Middle St. Johns	Upper St. Johns	Kissimmee	Indian River Lagoon
SW	Tampa Bay	Tampa Bay Tributaries	Sarasota Bay-Peace-Myakka	Withlacoochee	Springs Coast
S	Everglades West Coast	Charlotte Harbor	Caloosahatchee	Fisheating Creek	Florida Keys
SE	Lake Okeechobee	St. Lucie-Loxahatchee	Lake Worth Lagoon-Palm Beach Coast	Southeast Coast Biscayne Bay	Everglades

Figure 2: Overview of Florida basins and schedule (Drew, 2005)

In 2001, Florida's Environmental Regulation Commission approved the Identification of Impaired Surface Waters rule. This rule, established after broad consultation with a varied range of outside experts and vetted by public workshops and hearings (Drew, 2005), creates a planning list and a verified list. The planning list contains water bodies that may not be meeting WQS but do not have sufficient or reliable data to be placed on the 303d list. The verified list contains water bodies that fail standards and have sufficient data to be listed. The verified listing is then publicly adopted and administered and, lastly, filed to the EPA (Drew, 2005).

In 2008, Earthjustice (in conjunction with the Florida Wildlife Federation, the Conservancy of Southwest Florida, the Environmental Confederation of Southwest Florida, St. John's Riverkeeper and the Sierra Club) filed suit against the EPA for Florida's lack of numerical nutrient standards; at the time, the state had only narrative standards (Migliaccio, Li, & Obreza, 2007). Earthjustice claimed that the EPA formerly determined that numeric nutrient standards were necessary for TMDL consideration, as stated in the CWA. The EPA settled this lawsuit and agreed to advise numeric standards for lakes and flowing water by January 2010 and for estuarine and coastal waters by January 2011 (Migliaccio, Li, & Obreza, 2007) for the state of Florida (Table 1 and 2).

**Table 1: EPA numeric criteria for Florida streams (Migliaccio, Li & Obreza, 2007)**

Watershed Region	TN (mg/L)	TP (mg/L)
Panhandle West	0.67	0.06
Panhandle East	1.03	0.18
North Central	1.87	0.30
West Central	1.65	0.49
Peninsula	1.54	0.12

**Table 2: EPA numeric criteria for Florida lakes (Migliaccio, Li & Obreza, 2007)**

Lake Color and Alkalinity	Chlorophyll-a (mg/L)	TN (mg/L)	TP (mg/L)
Colored Lakes <sup>a</sup>	0.020	1.27	0.05
Clear Lakes, high alkalinity <sup>b</sup>	0.020	1.05	0.03
Clear Lakes, low alkalinity <sup>c</sup>	0.006	0.51	0.01

<sup>a</sup> Long-Term color > 40 Platinum Cobalt Units (PCU)  
<sup>b</sup> Long-Term color ≥ 40 PCU and alkalinity > 20 mg/L CaCO<sub>3</sub>  
<sup>c</sup> Long-Term color ≤ 40 PCU and alkalinity ≤ 20 mg/L CaCO<sub>3</sub>

Community involvement and public hearings are a key component to the EPA's revised TMDL mandate, and these elements have been incorporated into Florida's FWRA. Elements range from inclusion and participation of basin stakeholders (point and non-point dischargers, delegates from local government, Department of Agricultural and Consumer Services, agricultural commodity groups, local water management district, area businesses and industries, homeowners and environmental groups) and the inclusion of public water quality monitoring programs conducted by community organizations (Drew, 2005; Carriker & Borisove, 2009).

### **2.2.2: Implementation Process**

In TMDL methodology extensive data and monitoring is first required to analyze surface water conditions and identify impaired waters. Florida's Division of Environmental Assessment and Restoration within the FDEP handle the state's monitoring and data collection programs. With an adequate and complete dataset WQMs can begin the TMDL process.

TMDLs are constructed in a two-step process within the state of Florida. The first process involves the calculation and creation of a TMDL. In this process managers use collected data from the Division of Environmental Assessment and Restoration with GIS and modeling tools to simulate impairment loads and assign allocations to the various impairment sources. Once the final TMDL is created and allocations assigned a Basin Management Action Plan (BMAP) can be planned and implemented.

#### **2.2.2.1: Process Overview**

Basin Management Action Plans (BMAP) Managers connect with stakeholders to develop an action plan based on the constructed TMDL allocations. These plans are

implemented through an arrangement of regulatory, non-regulatory or incentive-based actions to achieve the desired pollution decrease. Non-regulatory and incentive-based actions include the formation of BMAPs, pollution prevention activities and habitat preservation and restoration (DeBusk, 2001). Regulatory activities include permitting for wastewater, stormwater or environmental resource. Permits may be numeric criteria or a combination of structural and non-structural BMAPs needed to achieve source decline (DeBusk, 2001; Drew, 2005).

The Florida Department of Agriculture and Consumer Services is accountable for developing and implementing BMAPs and assisting agricultural producers with implementation (Drew, 2005). The Office of Agricultural Water Policy, Department of Agriculture and Consumer Services work to institute BMAPs with input from consultants (Carriker & Borisove, 2009). These BMAPs are reviewed in conjunction with the FDEP and the Department of Agriculture and Consumer Services and verified in a generalized format using monitoring data. Any found deficient is reevaluated and modified or replaced (Drew, 2005).

#### **2.2.2.2: Hierarchy Listing**

Each state is required by the CWA, under section 303(d), to categorize waters where the effluent limitations are not rigorous enough to achieve water quality standards (Norgart, 2004). States' are required to establish a priority ranking for those waters identified, based on harshness of the pollution and the uses of that water-body (Norgart, 2004).

The FDEP has recently (~2014) constructed a method to evaluate the multitude of impaired waters listed in the verified TMDL list. This methodology is known as the Priority Framework, which assesses and weighs several factors designed to score impaired water bodies so managers can decipher which are the most important and net the most good.



Originally created by the EPA, the Framework analyzes factors including: presence of mercury, beach and bacteria impairments, presence of outstanding Florida waters, ecological significance, age of listing, environmental justice issues, designated use of water body, dissolved oxygen/biological oxygen demand/nutrients impairments, if verified by the IWR, points sources, proximity to other impaired water bodies and severity of impairment (FDEP, 2014). Weighing these factors, managers assign a score to each water body and along with public input they decide one which projects to begin TMDL implementation.

The Framework is touted by the FDEP as an efficient use of resources, holistically moving the process forward and giving the greatest chance for recovery. The process encourages TMDL alternatives in addition to creating a BMAP friendlier process in TMDL creation (FDEP, 2014).

### **2.2.2.3: Enforcement Mechanism**

Florida has a particular method for ensuring proper installment and follow-through for TMDLs. After BMAP managers consults stakeholders and create the final action plan (Stakeholders can opt out of implementing BMAP actions but must develop and maintain a water quality monitoring program to provide proof of no liability.), it is then agreed upon by the affected parties and signed and adopted into the FDEP Secretarial Order. This makes the BMAP enforceable with the penalty of fines or court levies (Hueber, 2010; FDEP, 2014). A non-point source that has demonstrated compliance with the BMAP by implementing basin management plans (BMPs) will be presumed by FDEP and the water management district to be in compliance not only with the BMAP, but also with state water quality standards and will be released from liability for the particular pollutant addressed by the BMPs (Hueber, 2010).

This measure is highly controversial because a non-point source that has chosen to demonstrate compliance by implementing BMPs and fails to properly follow the BMPs could also be subject to enforcement (Hueber, 2010). The legislature definitively means for BMAPs to be enforceable, but the language within the secretarial orders detail management strategies that encompass NPDES permits and other permitting structures. Current BMAPs are careful to detail all management strategies as enforceable by administrative or judicial action and need completion by the five-year period given in the FWRA. However, these new BMAPs are still written as planning goals rather than actual criteria driven enforcement mechanisms (MacLaughlin, 2015).

### **2.2.3: Criticisms and Complications with Program**

Florida's TMDL program is continually evolving and with continued assessment and monitoring. Water quality assessment as of 2010 has been gauged at 20% of rivers and streams, 54% of lakes, ponds and reservoirs with all 1,005 of bays and estuaries accounted for. Of those assessed, 80% of rivers and streams, 90% of lakes, ponds and reservoirs and 97% of bays and estuaries have been listed as impaired (U.S. EPA, 2013). Reliable data will allow for better modeling and effective management solutions. Some of the issues encountered are timeframe issues, as federal/EPA mandates require a stricter timeframe for TMDL development than the allotted five-year plans in the state strategy (Drew, 2005). The same issues of scientific and data validity affect the program as with other TMDL plans.

The legality of the FWRA has also been questioned, and the legal relationship between basin plans and permits needs strengthening. This effort would be to preempt frivolous lawsuits rather than stymie public participation and involvement. Environmental groups and activists have argued that IWR delayed regulatory action and created a loophole for polluters to use to bypass TMDL creation and implementation. The arguments of "sound

science” and “adequate data,” as described by Houck, is prevalent in delaying moving from the planning list in the rule to the verified listing (Norgart, 2004).

Funding remains a critical issue for TMDL programs, with Florida being no exception. Problems exist in procuring funds from a variety of sources with no actual revenue based solely for TMDL purposes; managers must hodgepodge different networks of monetary sources to meet budgets. There have been proposed fees/taxes placed on materials that lead to non-point pollution (fertilizers, pesticides, etc.). The FDEP currently institutes a loan program (Clean Water State Revolving Fund) to provide financial assistance to communities to build or improve water quality improvement projects (Drew, 2005; Migliaccio, Li, & Obreza, 2007).

Other complications include TMDLs requiring reduction below what would be considered natural conditions for certain water bodies. An example of this would be Alachua Sink, which would need a reduction in water flow to accommodate the prescribed TMDL (which would adversely affect the habitat) if not for a revision in the mandate (Goodman, Hutton, Roberts, & Grippo, 2006; Drew, 2005).

### **2.3: Florida vs. National TMDL Program Comparison**

As discussed previously, the national TMDL program is a point of emphasis and guidelines for the establishment of state programs. It is a federalist type of program of an overarching set of regulations that serve as a primer for states to create their own set of water quality regulatory programs.

Florida’s TMDL program is different from many state systems and has a few elements that broaden or strengthen the backbone legislation found in the national TMDL program. Florida’s developmental process created through the FWRA and its enforcement mechanism offer an intriguing case and example in TMDL law.

Florida has 6,539 (FDEP, 2014) water bodies assessed in 2014; nationwide data is lacking with state assessment reporting. Nationally, there are 42,459 impaired waters listed by state environmental departments in the 303d listing, Florida represents 2,292 of these or 5.4%. The top three causes for impairments nationally are pathogens (10,810 water bodies affected), nutrients (7,705 water bodies affected) and metal contamination other than mercury (7,032 water bodies affected). Florida's top three sources of impairments are mercury (1,128 water bodies affected), organic enrichment/oxygen depletion (1,049 water bodies affected) and pathogens (608 water bodies affected) (EPA (b)(c), 2014). Florida, as of 2010, has had 55 waters delisted for compliance with water quality standards; nationwide compliance figures are at 3,055 water-bodies delisted (U.S. EPA (c), 2014).

### **2.3.1: Process Overview**

The steps of the national TMDL program in the development of water quality standards, impaired water bodies listing and TMDL creation and implementation can be seen as guidelines and requirements states must use in the creation of their program. Florida builds upon these specifications and installed, with outside consultation, its own methodology to help navigate the process and streamline results.

Florida, having both confronted its own litigation and observed the same in other states and the national program, recognized the need for thorough, accurate and inclusive data as the most essential foundation in creating a successful TMDL program. Having a division with the FDEP to monitor environmental factors helps the state's extensive data collection and gives major flexibility to other departments to create legislation and action plans to combat habitat and resource degradation.

With adequate data, Florida's TMDL program separates the process into two distinct but highly interconnected operations. The first process consists of TMDL development and

the next phase concerns BMAP creation and implementation. This creates two distinct sets of water quality managers: those who work on a quantitative and modeling side who create the necessary numerical values and allocations, and managers who work in a more qualitative function that network with stakeholders and affected parties in creation of an action plan to meet TMDL requirements. This is an innovative approach as it defines roles that are not mutually exclusive but have differing functions. They rely on each group but are free to focus on a set task in fulfilling the TMDL process.

### **2.3.2: Enforcement Mechanism**

The most unique process differing between the national TMDL program and Florida is the presence of enforcement mechanisms and related legal recourse. The national program does not define how states are to enforce TMDL protocols, relying on legislature as precedent to hold in court. Without clear definitions for penalties for incomplete or negligent follow through by stakeholders, states have had to field their own properties in creating repercussions and enforcement.

Florida's method of creating a secretarial order gives BMAPs the weight through a hefty fine and court liability. With Florida Statute 403.067(7)(b) 2.h, the FDEP has a clear course of action that can be used against uncooperative stakeholders.

## **CHAPTER 3:**

### **CONCEPTUAL FRAMEWORK**

To study the process and concepts that WQMs use in BMAP decision-making, a theoretical and conceptual framework must be developed through past research in decision analyses. This framework allows the formulation of an appropriate methodology to ascertain purposeful and exploratory data to investigate the proposed research questions. The conceptual framework, previously discussed in the Literature Review section on Public Policy Analysis, to derive this information is structured as follows.

Through the literature of the TMDL process and decision making studies, several concepts have shown to reflect the processes used by environmental managers in formulating decisions. This study utilizes key concepts in decision-making theory from social science based studies and Public Policy analysis concepts to synthesize a methodological framework to probe how managers synthesize data and various stakeholder concerns to approach the problem of non-point source pollution. These concepts include the Rational-Comprehensive Model, Multi-Criteria Decision Analysis and its Analytical Hierarchy Process model, and lastly, Adaptive Management principles that recently have proliferated in environmental management.

### **3.1: Public Policy Analysis**

This study combines three components of Public Policy Analysis to delineate methodology and analysis. The three methodological sources include: Ration Decision Making, Multi-Criteria Decision Analysis, and Adaptive Management.

#### **3.1.1: Methods of Analysis**

Making policy and planning decisions requires strategic thinking. This type of thought process involves leadership and an understanding of the science of management (Allen and Coates, 2009). WQMs must lead stakeholders and their management teams into making a cohesive, practical, and efficient plan to curb water pollution. This responsibility is often referred to as “adaptive work” and calls for leadership to consider broader consequences of the situation, take a role in labeling the problem, explore prospective solutions, and apply actions as what *should* be done (Heifetz, 1994). The problems faced in strategic decision-making are often described as “ill-structured,” “messy,” or “wicked problems;” they do not have quick and easy solutions and require intense analysis and deliberation (Allen and Coates, 2009)

Many useful models conceptualize strategic decision-making, including the ones listed below (Allen and Coates, 2009):

1. Rational Model
2. Bounded-Rationality Model
3. Incremental Model
4. Mixed-Scanning Model
5. Polis Model
6. Garbage Can Model
7. Bargaining Model

## 8. Participative Model

The decision-making model focused on in this study is the Rational Decision Making Model (commonly known as Rational-Comprehensive Model). Its structure represents a clone of the implementation and development process the Florida and National TMDL programs are based on and represents a scientific method-based decision model. The model draws from economic theory and prioritizes productivity by picking the best option based on specific standards (Allen and Coates, 2009). The model gives a structured way to analyze a problem and derive a solution based off a rational, scientific methodology. The disadvantage of this model is that it has shown to be best suited for simple problems; the ambiguity of the environment can damage the confidence in determining the solution and the consequences of all alternatives (Allen and Coates, 2009). Overall, the model offers a closely related structure that the TMDL development follows and highlights an area of focus for this study: how do WQMs organize and structure data and solutions into making a comprehensive decision in BMAP creation?

### **3.1.2: Multi-Criteria Decision Making Analysis**

To further evaluate decision making process in WQMs, a methodology to derive meaningful information from the structure WQMs use in evaluating details and choosing BMAP options must be developed further. Multiple-Criteria Decision Analysis (MCDA) helps evaluate the relative importance of multiple objectives and information to a diverse group of experts. MCDA is commonly used to provide transparent, structured, rigorous, and objective evaluation of multiple criteria (Hajkowicz, 2008).

Several studies have shown the importance of including stakeholder preferences in environmental management (Pomeroy and Dover, 2008), but most MCDA studies



focus on the general public with few focusing on the opinions of experts with direct application to public policy (Ryu, Leschine, Nam, Chang & Dyson, 2011). This study uses MCDA to help create a focused analysis of WQMs' ranking of multiple pieces of information and management options.

The Analytical Hierarchy Principle (AHP) is one of the most widely used methods in MCDA and provides a framework for planning, priority setting, and resource allocation (Saaty, 1988). Developed in the early 1970s, AHP has been used in a variety of fields to analyze the preferences for management objectives and alternatives (Ryu et al., 2011). Mardle et al. (2004) detailed the AHP methodology as outlined below:

1. Develop a hierarchy of interrelated decision objectives, describe the problem, and create a survey format
2. Perform a criteria-oriented pairwise comparison, which is based on the survey using a 9 point scale
3. Compute local priorities based on respondents' relative weights for the decision criteria and evaluate the consistency of comparisons using the maximum eigenvalue method (Saaty, 1988)
4. Aggregate local priorities using arithmetic mean

Consistency is a major component in AHP and is measured by the largest eigenvalue obtained through step 2 (Ryu et al., 2011). Using the AHP methodology, we analyze through 3 decision matrices: an information-based model, an objective ranking in regards to stakeholder cooperation, and management options (BMAP alternatives, or methodologies to implement).

### **3.1.3: Adaptive Management**

Adaptive management (AM) is a widely suggested management methodology for decreasing ecological ambiguity and improving the performance of many resource-based management plans. Developed by ecologist C.S. Holling (Holling, 1978) the management style takes an experimental, akin to the scientific method, approach to help reduce the uncertainty commonly found in environmental management. Currently, plans use best available information to approximate the parameters a system should function within and implement a single plan to best manage the resource. AM recognizes uncertainty and proposes a range of management plans that should be refined over time based on results (Gregory, Failing, & Higgins, 2006).

There are two general methods to AM as described by Walters & Holling (1990), active and passive. Active AM uses planned manipulation of the environment by testing a series of management actions. Active AM generally requires more time and money but can greatly improve scientific knowledge of the resource. Passive AM involves evolving hypotheses about system parameters and using best available data to create a management plan to then monitor, allowing for refinement of the original hypotheses, goals, and management actions. The short-term results found in passive AM make it a favorite for government officials. Both plans have benefits; environmental managers must properly incorporate elements of AM into their plans to maximize their system's efficiency. Some studies have called for AM to be a specific, targeted initiative within a broader management plan rather than a general management approach (Failing, Horn, & Higgins, 2004).

AM supports the evolution of environmental decision making from an optimized control to flexible, adaptive control. It hypothesizes the inherent uncertainty and unpredictable elements in environmental management and provides a framework in which environmental managers can develop comprehensive action plans (Linkov, Satterstrom,

Kiker, Batchelor, Bridges, & Ferguson, 2006). Large field studies have shown AM works best when early field experiments on method feasibility are phased in such a way that they inform later hypothesis testing to show which methodology is superior (Doherty et al., 2011; Zedler, 2016) Florida's TMDL program and BMAP creation strategies incorporates AM elements (use of public participation, adaptive management goals, and five years revision timeline) so the understanding of AM fundamentals is crucial for the development of MCDA decision matrices. Understanding the goals of the program allows the focus of the survey questions to concentrate on definitive rudiments needed to make significant statements on the decision prowess of WQMs and identify gaps in the developmental process.

### **3.2: Rational-Comprehensive Model**

Rational-Comprehensive Model (RCM), or Rational Decision Making, was developed from economic theory of maximizing efficiency through choosing scenarios based on certain criteria. It assumes the decision-maker can identify the problem, rank their values and goals based on their importance related to the overarching goal, and properly weigh the advantages and disadvantages of each alternative. This is described as the six-step process below (Allen & Coates, 2009):

1. Define Goals
2. Identify options
3. Estimate the costs
4. Decide the favorable option based on a ratio of benefits to costs
5. Monitor execution
6. Restart process

The process is straightforward and effective for simple problems with clear definitions. Environmental management issues are rarely simple, but the structure works well

for technical issues that have a general agreeance on precise definitions for goals and measures for the analysis of alternatives. TMDL litigation is structured in a manner similar to the RCM methodology. Florida is supported with many “textbook” methods for defining the appropriate goals and measures needed, so the RCM is a useful construct to begin this study’s investigation.

Using the model’s structure, certain questions on the steps WQMs use in creation of BMAPs to achieve the final TMDL plan can be derived. Questions related to the analysis of objectives and options available lead to important deductions that reveal fallacies or strengths in the development process. Knowing how a WQM researches alternative methods is useful in the same regards, and understanding the collaboration used by the Florida’s TMDL program with Florida’s Monitoring and Assessment branch produces purposeful data on possible improvements to the process in use by FDEP. To fully utilize this model, analytical help from a closely related methodology known as Multi-Criteria Decision Analysis, used in many social science based decision studies, is needed.

Taking from AHP we developed a methodology to actively engage WQMs do delineate their preferences for several options and comparisons. We then use RCM and AM to analyze for themes and determine how WQMs adapt their management style to the tasks of developing BMAPs and coordinating with stakeholders.

## **CHAPTER 4:**

### **RESEARCH DESIGN AND METHODOLOGY**

The following section summarizes the study methodology to investigate WQMs decision-making process and ranking hierarchies in Florida. This methodology produces meaningful information that is analyzed to generate relevant, helpful knowledge regarding program implementation.

#### **4.1: Problem Statement and Objectives**

This study investigates the processes of those who implement the program practice to construct successful basin management plans to meet TMDLs. Knowing the objectives that are being focused on, the elements of successful management, commonalities, and sources of frustration/problems encountered prove beneficial for policy makers and incoming WQMs. Policy makers can tailor existing or upcoming legislation to facilitate WQMs in meeting management goals while incoming WQMs can use preexisting data as a means to familiarize themselves with the methods that have worked previously or possibly areas that can be expanded or tested. The overall objectives for this study are:

- Understand the viewpoints and importance of differing components that WQMs place towards the TMDL program during the processes of development and implementation
- Understand the complications faced by WQMs, discuss the factors hindering the program in relation to its benefits while exploring commonalities and successful elements

- Understand the processes, tools, and conveyance methods used by WQMs in the TMDL process

From these objectives, the following main research questions have been devised to work from in relation to the hierarchies used by WQMs and the overall perceptions:

- Do WQMs favor more direct data rather than modeled or periodical information; will the largest preference be previous case studies/examples?
- Will stakeholder knowledge translation be a key component to BMAP success and scientific knowledge is the most favored attribute?
- Are agricultural non-point related BMAPs the most relied on management method?

The results of this study will address these secondary research questions:

- What are WQMs' perceptions towards the TMDL program?
- What hierarchy, within the TMDL process, do managers use to meet differing water quality goals and stakeholder concerns?
- What works and what does not work within the regulation and the managerial process?
- What are the elements for developing and implementing successful TMDL programs?
- What are the biggest obstacles in TMDL development and implementation; what are some common complications?

## **4.2: Rationale and Significance**

The significance of this type of study is its ability to measure the opinions and viewpoints concerning the TMDL process. Knowing how WQMs value different characteristics and processes presents valuable information in determining policy direction and can give legislators the proper information on making policy recommendations. The use of the analytical hierarchy principle from MCDA contains many elements needed to

accurately gauge WQMs viewpoints. Scaling their preferences for certain qualities has implications to scale preferences for management options and information usage.

### **4.3: Methodology Overview**

The sample design for this research project is comprised of a survey administered to WQMs via email consisting of questions about the efficacy and managerial aspects of the TMDL program.

The sample population for this study is the WQMs of the state of Florida. As stated in the literature review, two distinct groups in Florida are involved with water quality management: The first group works directly in analyzing assessment data and creating the TMDL; the second group works with stakeholders in creating and implementing the BMAPs. Since the first group deals with collected and modeled data to create the TMDL, it is more quantitatively based with empirically derived data.

The focus of this study is the second group. BMAP managers deal with multiple options and conflicts, making use of various decision-making methods and theories to create a comprehensive basin management plan. These elements are reviewed by the study and analyzed for statements regarding the program. The sample population has varying degrees of education, experience, and personal and professional backgrounds; this information is not used in any means. Confidentiality is insured for respondents through proper data encryptions and elimination of any personal markers from the results.

To assess the processes and viewpoints of WQMs involved with the development and implementation of TMDL programs within the state, this study incorporates qualitative data collection and analyses, specifically surveys. This technique allow us to approach the research questions in a manner that creates inclusivity into the managerial process and

provide the necessary insight into the program that allows for recommendations for improvements in process efficiency and results.

### **4.3.1: Survey**

In order to ascertain perspectives and insight of WQMs, the basic qualitative method of an online survey was implemented. Given the lack of resources and the brief window of free time WQMs possess, it was determined that a survey provides a larger, more varied response in which proper analysis and themes can be developed for the state program as a whole. The survey was used to gauge the opinions of managers regarding the planning and implementation process of TMDL development, diagnose common complaints, and derive possible solutions for a more effective, efficient process. With this dataset, specific studies can be suggested for more in-depth analysis. Since the study involves interaction with human subjects, certification from the Institutional Review Board (IRB) was obtained, specifically a non-medical IRB (Appendix B).

WQMs were selected with the help of Kevin Coyne, Program Administrator for the BMAP program in the FDEP. The relayed contact information consisted of those who had recently completed or were in the process of developing BMAP projects and resided in several counties in differing watersheds. Of the compiled list of 24 possible WQMs provided by the FDEP, 13 responded and attempted the survey, giving a completion rate of 54%. Only one reported not being able to complete the entire survey, as the questions did not pertain to their function with BMAP development and implementation. WQMs who were unable to respond mentioned a lack of time to adequately go through the survey; some commented they were either too new or had not participated in the BMAP or TMDL process.

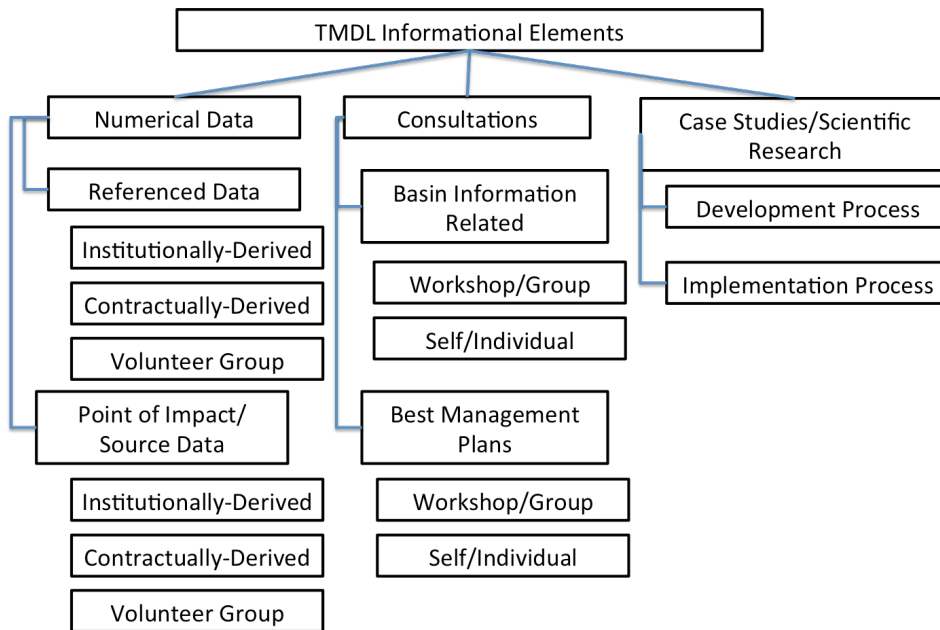
WQMs were contacted via email to notify and gain permission to administer the survey. This contact was carefully scripted to ensure that proper, precise communication is



relayed given the need for data and the limits on time regarding the subjects. We discussed the study's objectives and attempted to generate interest in the study with WQMs, the intention was to produce an investment by WQMs into the study to ensure timely, accurate responses. Managers were then contacted through the online survey service 1KA (<http://english.1ka.si/>) to link WQMs to the survey and ensure an adequate turnout and prompt, thorough results that online methods were capable of producing.

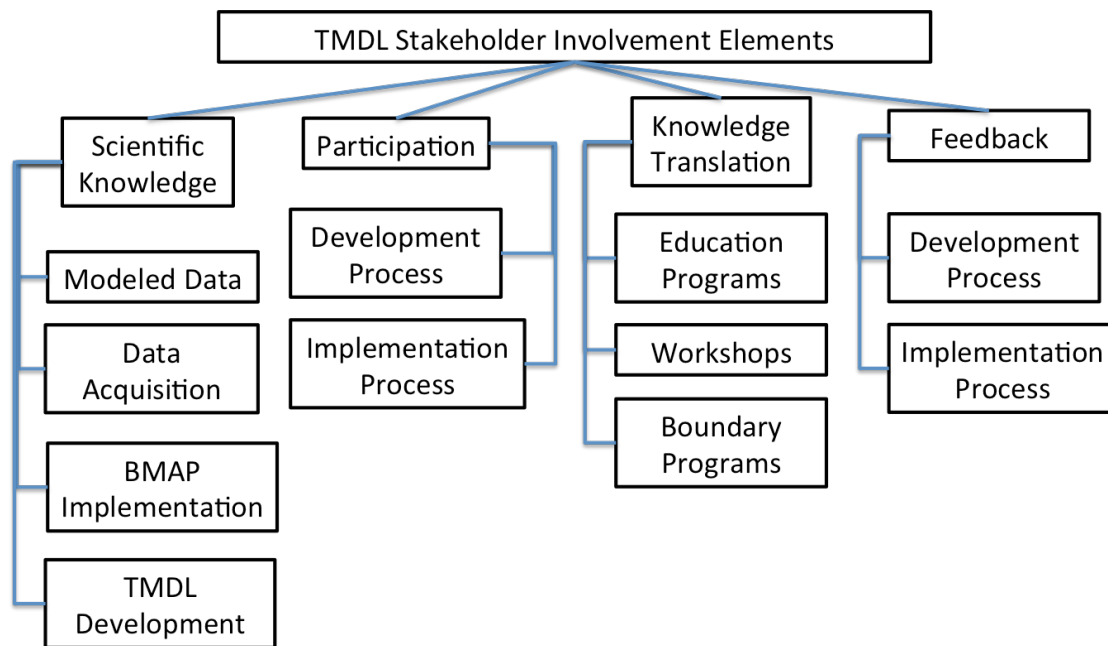
The survey was developed through use of the AHP method based on the MCDA process. Here, three decision matrix models were developed through the literature review. Each model was divided into tier 1 criterion with tier 2 and further subdivided into tier 3 for each category. These matrices (figures 3, 4, and 5) were shared and modified according to experts in the field.

TMDL Informational Elements (Figure 3) is broken into the tier 1 criteria: numerical data used in the TMDL calculation, consultations from outside environmental professionals and case studies or scientific research. Numerical data is divided into referenced data, or data collected from neighboring datasets or points, and point of impact. This is further divide into three subsets: institutionally or from the department itself, contractually or developed outside or volunteer which is developed from public groups.



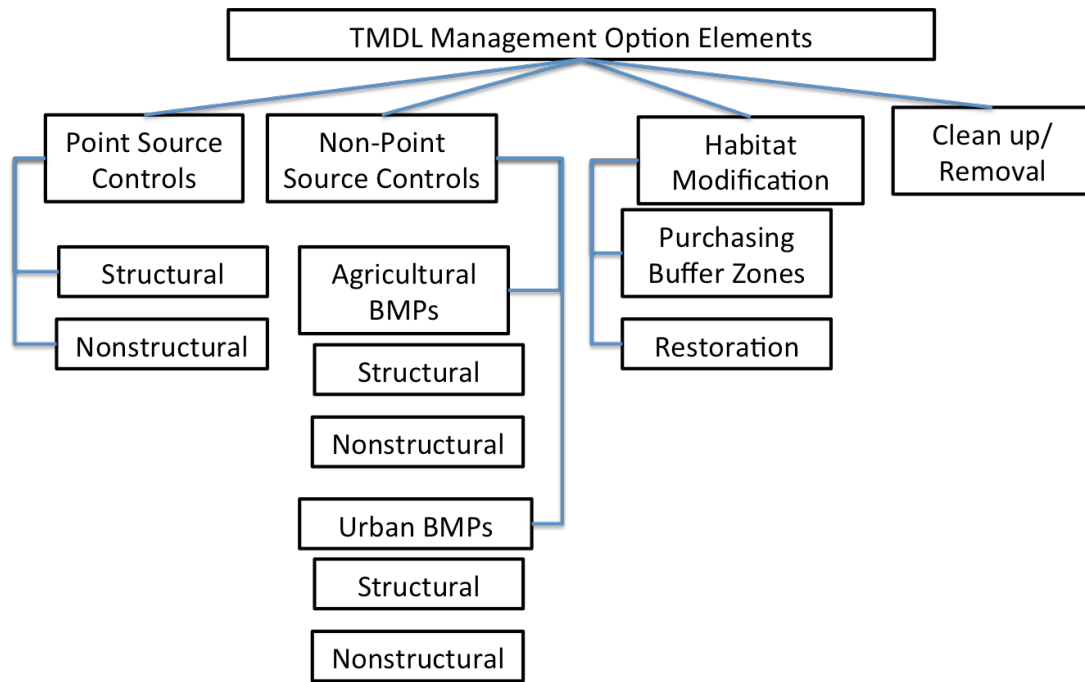
**Figure 3: TMDL Information Elements Hierarchy**

TMDL Stakeholder Involvement Elements (Figure 4) has four tier 1 criteria elements: scientific knowledge, participation, knowledge translation and feedback. Scientific knowledge is broken into four different subsets asking which element is preferred: knowledge of modeling data, how data is acquired, how BMAPs are implemented or TMDL developed. Participation and feedback only ask which phase (development or implementation) they are preferred in. Knowledge translation looks to compare education programs developed by the department, public workshops held by the FDEP or boundary programs from universities or extensions offices on WQMs choice.



**Figure 4: TMDL Stakeholder Involvement Elements Hierarchy**

TMDL Management Options (Figure 5) investigates managers' preferences or opinions on several pollution control options. There are four tier 1 criterion: Point and Non-Point Controls, Habitat Modification and Clean up/Removal. Point Source Controls are divided into structural (infrastructure upgrades or wastewater processing improvements) and nonstructural (permitting changes for wastewater or stormwater MS4 updates). Non-point is broken into Agricultural or Urban BMPs, which are further divided into structural and nonstructural. Examples of structural agricultural BMPs include land modification (berms), water-controlling devices or fencing; nonstructural includes irrigation or nutrient permitting changes. Structural urban BMPs include stormwater collection system upgrades or infrastructure upgrades, while nonstructural are ordinances changes or permitting regulation. Habitat modification has two tier 2 criteria: Purchasing of buffer zones around WBIDs and habitat restoration. Clean up or removal groups dredging activities and brownfield clean ups.



**Figure 5: TMDL Management Option Elements Hierarchy**

The survey configures the relative importance of each objective by asking the WQM to rank each set on a scale of 1-5 for its importance, both in its bracket and against all other objectives (survey is located in the Appendix A). The survey included follow-up questions, asking the WQM to explain their choices. As seen in the addendum the survey was originally in a 9-point comparison scale but this was later readjusted to a 5-point under the recommendation of survey reviewers. The questions are outlined divided into three sections based on the hierarchy model they correspond with. The survey's first seven questions are based off the TMDL informational Elements, Questions 8, 9, and 10 are derived from the TMDL Stakeholder Characteristics hierarchy while Questions 11 through 16 deal with the TMDL Management Options hierarchy. The last question asks WQMs to compare the hierarchies against each other. The following is a brief explanation of each question with reasoning for its inclusion.

- 1) Of three information sources used in TMDL development (Numerical Data gathered by the DEP, Professional Consultations from outside organizations including other

government branches and volunteer sources, and Case Studies/Scientific Research previously conducted on the WBID) what is your preference related to each?

This overarching section question asks managers to evaluate the data sources present in TMDL calculations and BMAP development and decide their relation to one another. This question is further investigated in the following section questions.

- 2) In regards to Numerical Data gathered by the DEP, what is your preference regarding how this data is derived from: point of impact/source or data that is referenced from neighboring WBIDs?

Question 2 specifically asks WQMs to evaluate numerical data used in TMDL development on their preferences for data from the WBID or source in project being developed or modeled from neighboring locations.

- 3) What is your preference regarding the source for Referenced data used in the TMDL development; derived from within the organization, volunteer group or obtained from an outside company/organization?
- 4) What is your preference regarding the source for Point of impact/source data used in the TMDL development; derived from within the organization, volunteer group or obtained from an outside company/organization?

Here WQMs are asked for their preference on where modeled data is derived: by the FDEP or county government, received from a consulting group, or provided by public volunteer groups. The same process is questioned in Question 4 but for data collected at the point impact or direct source.

- 5) How do you prefer to research information regarding the basin site: brainstorming with a group/workshop with other BMAP managers or Stakeholders, or as an individual researcher?
- 6) How do you prefer to research information regarding basin management action plans: brainstorming with a group/workshop with other BMAP managers or Stakeholders, or as an individual researcher?

For Questions 5 and 6 the survey inquires how WQMs research the basin of the WBID and possible management plans either in a group setting or simply as an individual.

7) In which process is Case Studies/Scientific Literature most helpful for?

The last question for the TMDL Informational Elements asks managers' to select which phases scientific literature or case studies are most helpful for either the development or implementation phase. Each of these first seven questions is directing WQMs to rank their data preferences in both TMDL creation and their final BMAP development. Each choice is meant to signify where managers' believe the strongest data source is and what they believe to be the most accurate. This can help the FDEP to strengthen data monitoring or provide training on data acquisition. The survey then transitions into the second hierarchy to investigate preferences on stakeholder attributes and involvement.

8) What are your rankings regarding these three traits of Stakeholder characteristics: Scientific Knowledge regarding the TMDL process and water quality impairments, Feedback in creation of BMPs and basin information, and Participation with the implementation process?

Question 8 looks to identify which of the three identified stakeholder qualities are favored. Here WQMs must rank providing feedback, participating in the TMDL project or just having applicable knowledge of the process is beneficial to the success of the program.

9) Which related qualities are preferred in Stakeholder Scientific Knowledge: knowledge in Modeled Data, Data Acquisition, BMAP Implementation, or TMDL Development?

This query analyzes which of four attributes is favored regarding scientific knowledge: knowing about modeled data or how data is acquired, how a TMDL is developed or how a BMAP is implemented.

10) What is your preference for Stakeholder participation regarding the BMAP development process or the implementation process?

For Question 10 the survey asks WQMs to choose between having participation in developing the BMAP or implementing it.

11) In your opinion which method is better for educating Stakeholders on the TMDL and BMAP Processes: Educational Programs through the internet or printed materials, Workshops sponsored by the water management district, or Boundary programs through different government departments or other related institutions, such as universities?

At the end of this section the survey asks managers to rank three different mediums used to inform the public on TMDL activities. Programs developed by the FDEP such as online media, courses or reading materials, workshops held within the water management districts or boundary programs which are developed in coordination with universities and extensions offices. These questions are designed to have WQMs evaluate stakeholder involvement along with the background knowledge they may possess. Since stakeholders' involvement is encouraged and public review is required knowing what WQMs see as advantageous can help the program continue efforts to engage the public and elicit valuable involvement. The last section of the survey looks to evaluate the management options WQMs use.

12) What is your preference related to these Management Options: Habitat Modification (buffer zones, restoration, etc.), Non-Point Source Controls (Structural or Non-Structural BMPs), Point Source Controls (Structural controls such as mandated process improvements or infrastructure upgrades; or Non-Structural methods such as permitting increases on NPDES and MS4s), or Cleanup/Removal activities (dredging/brownfield site restoration)?

The section starts by asking WQMs to gauge which management option out of point, non-point controls, and habitat modification or clean up. Follow up questions are then employed

to task managers to detail specifics about the most literature-cited resources of non-point and point controls.

- 13) In regards to Point Source Controls (Structural controls such as mandated process improvements or infrastructure upgrades; or Non-Structural methods such as permitting increases on NPDES and MS4s), which do you believe to have the most impact or to be the most effective?

Question 13 investigates which type of point source control is preferred either structural or nonstructural. Question 14, 15 and 16 investigate non-point source controls. First it asks WQMs which of urban or agriculture BMPs is most effective. Questions 15 and 16 take these two potential methods and ask which controls (structural or nonstructural) are most useful.

- 14) With Non-Point Source Controls which is the most effective?

- 15) In relation to Agricultural BMPs which are you preference Structural controls (Land Modification, structural improvements i.e. water control devices, fencing etc.) or Non-Structural (regulation on irrigation, nutrients, etc. or permitting changes)?

- 16) In relation to Urban BMPs which are your preference Structural controls (upgrades to infrastructure, wastewater upgrades, storm water collection, etc.) or Non-Structural (Ordinance changes, permitting management, regulation of fertilizers, etc.)?

The last question of the survey asks managers to rank each of the hierarchies in relation to each other.

- 17) Taking into consideration all the elements that make up each section (TMDL Informational Elements, Stakeholder Characteristics, and Management Options) how would you rate each section in relation to the others?

The goal of the survey is to find qualitative data about the program's pros and cons.

The data details the process from those directly responsible for the creation and maintenance of the program. The survey was short in length to give consideration to the limited timeframe



managers have allotted; participants' identities were kept anonymous for their protection and privacy. Making the survey efficient in questions has the added benefit of improving respondent complementation and eliciting a quicker response.

The survey data can be analyzed and produce common analysis themes related to the management process as well as providing an overview into the insight of the state program held by WQMs. The data can also produce useful statistics regarding the WQMs' viewpoints on the program as a whole. Specifically, following questions about the program can be answered: is it working, what is needed for success, potential hazards in the process?

### **4.3.2: Methods of Analysis**

To construct the survey and accurately analyze WQMs' viewpoints, the methodology detailed in Mardle et al. (2004) was employed:

1. Develop a hierarchy of interrelated decision objectives, describe the problem, and create a survey format
2. Perform a criteria-oriented pairwise comparison, which is based on the survey using a 9 point scale
3. Compute local priorities based on respondents' relative weights for the decision criteria and evaluate the consistency of comparisons using the maximum eigenvalue method (Saaty, 1988)
4. Aggregate local priorities using arithmetic mean

As stated previously, consistency is a major component in AHP and is measured by the largest eigenvalue obtained through step 3 in the above methodology (Ryu et al., 2011).

Comparisons matrices are completed for each question and then eigenvalue calculations (Saaty, 1988) were applied to determine the full ranking of each option.

Consistency ratios were then calculated to determine the validity of the rankings in reference

to the full rankings from all respondents. To analyze respondents' ratings of the survey questions, the weights were computed for each choice based on the rankings reported. From these weights, objectives were then ranked and determined the importance of each to the community. To ensure the accuracy of this data, a consistency ratio (CR) was computed, each question was broken down into a comparison matrix and eigenvalues were compiled. From this, the consistency index was derived by the maximum eigenvalue of the matrix using the equation  $(\lambda_{max} - n) / (n - 1)$  where  $\lambda_{max}$  is the maximum eigenvalue and  $n$  is the number of comparisons (Saaty, 1988). The CR is derived from this equation Consistency Index/RI(n); RI is the random consistency ratio derived from a predefined ratio based on the number of comparisons used in the matrix (seen in Table 3).

**Table 3: Random consistency indices for different number of criteria (n) (Saaty, 1980)**

n	1	2	3	4	5	6	7	8	9
RCI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

*\*Where n is the number of comparisons and RCI is the Random Consistency Indices*

The results of the survey were weighted, ranked, and each CR was measured. For this study, Saaty's (1988) original limit of 10% was used. The CR shows the percentage of possible inaccuracy that each question's comparisons could have. Values higher than the 10% limit denotes that the objectives are too similar to be accurately compared.

Survey results were added into AHPcalc excel file, published by Klaus D. Goepel. The template ease of use aided in the calculation of the relevant AHP statistics. Included in the analysis is the Geometric Consistency Index (GCI), which is the direct analog of the CR. The GCI is used similar to the CR, as a means to accept or reject inconsistent pairwise comparison matrices. If this value is more than the 0.10, defined by Saaty (1980), the matrix is invalid and its options too similar to derive any useful data. This method can only be used in matrices that have more than two choice options.

## **CHAPTER 5:**

### **STUDY AREA AND DEMOGRAPHICS**

Florida is a peninsula located in the southeastern most part of the United States; it is the 22<sup>nd</sup> most extensive state with a total area of 65,755 square miles (U.S. Census, 2011). Its climate ranges from a transitional zone of temperate to subtropical in the north to tropical in the southern portion of the state. Summers are long with periods of warm, humid air; winters are generally mild with the occasional cold front. On average, rainfall consists of 60 inches within the year usually coinciding in a short, wet season; historically Florida has periods of flooding and droughts, the spatial and temporal variability of which can lead to water shortages (Southeast Regional Climate Center, 2011).

Geologically, Florida's landscape consists of porous karst limestone atop of bedrock (the Florida platform) with predominately sandy soils. Florida is relatively flat with its highest elevation at 345 feet above sea level (Americasroof.com, 2012). Hydrologically, Florida is immense, both in the quantity of water bodies and variety, with an estimated 52,000 miles of rivers, approximately 800 lakes, 4,500 square miles of estuaries and bays, and more than 700 spring systems (Drew, 2005). The state ranks third in the United States for inland water area (Morris & Morris, 2009). Surface drainage and topographical relief are greatest in rivers entering from the north and northwest, and most are alluvial. The land profile flattens moving further south, with drainage becoming less distinct, slower, and non-alluvial (FDEP, 2012).

Florida is the third most populous state in the United States of America with a population numbered at 19 million (U.S. Census, 2015). Florida is also expected to gain 1.8

million people through international immigration through present to 2025, the third largest net-gain in the country (Campbell, 1997). Its population is diverse with differing cultural, economic, ideological, and educational backgrounds. Florida's economy is marked by agriculture, mining, tourism, and commercial industries.

Florida depends on its water resources for a variety of uses, including monetary with \$8.2 billion dollar fishing industry and \$62.7 billion in tourism (Morris & Morris, 2009; Florida Commission on Tourism, 2012). The variety of Florida's habitats and the diversity of its stakeholders present numerous challenges to the study group or water quality managers. While many point sources of pollution, such as sewage treatment plant discharges, have been had their impact reduced, addressing pollutant loading from widespread, diffuse non-point sources, such as urban development and agriculture, remains a challenge (FDEP, 2012). Figure 6 shows the adopted TMDLs currently underway in the state of Florida (FDEP, 2015).

Water quality managers have been divided into five separate groups based on water basins (an effort created by the FWRA to manage on a watershed basis). In these districts, managers develop, implement, and monitor TMDL plans for the 52 major hydrologic basins. Each district also manages the flow, land use, and development within its area. Florida's TMDL program divides each basin into five groups and runs these groups through a five-stage process in developing TMDL plans. The age, sex, and educational background are diverse for this group of managers; this information is not used in any means. Confidentiality is insured for respondents through proper data encryptions and elimination of any personal markers from the results.

An overview of the adopted TMDLs for the state of Florida can be seen in Figure 6. Here TMDLs are labeled with the color brown, lead is color coded as dark blue, fecal coliforms as green, dissolved oxygen as light blue and lastly grey designated iron impairments.

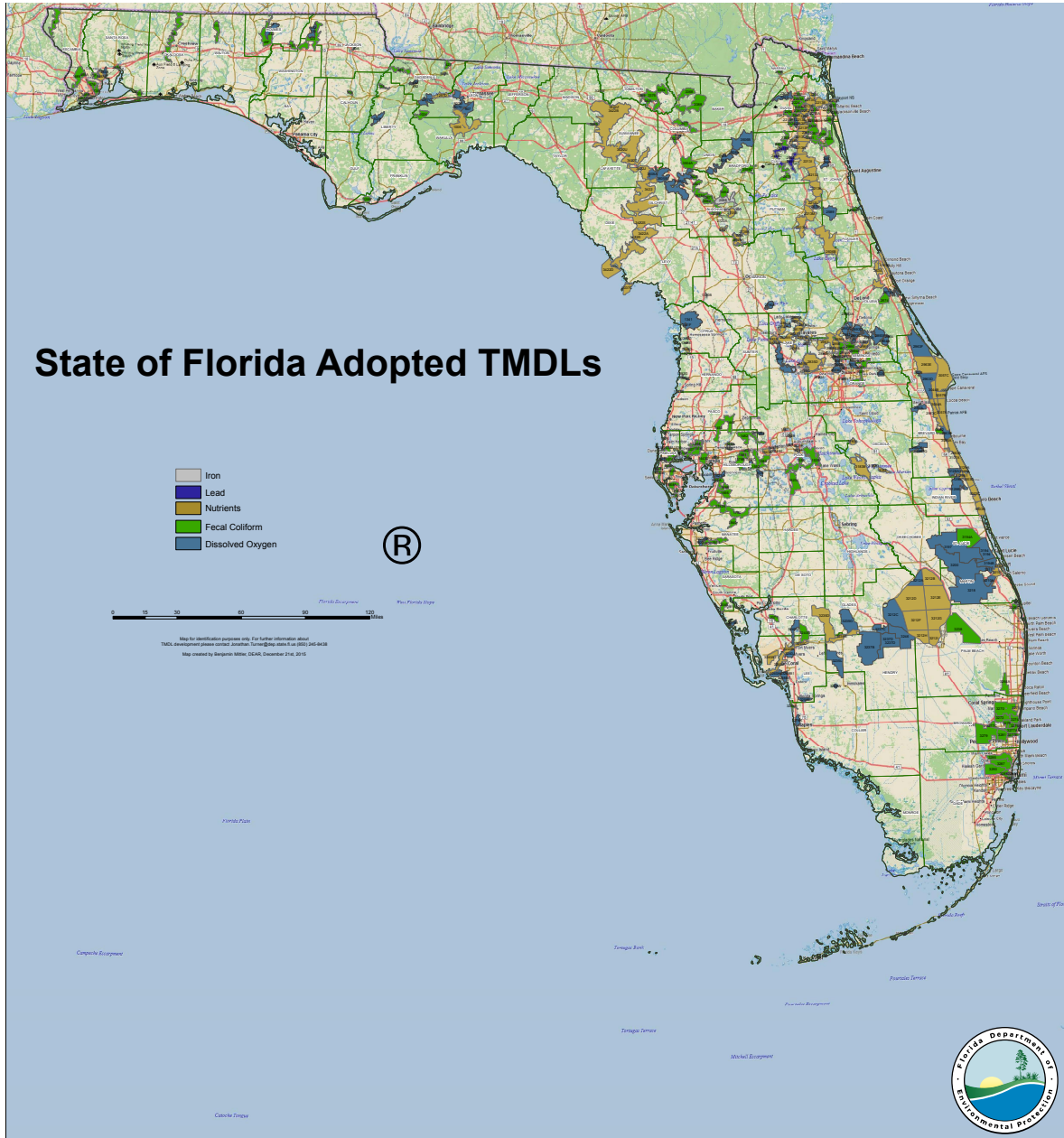


Figure 6: Overview of adopted TMDL Projects (FDEP, 2015)

## CHAPTER 6: RESULTS

The following chapter details the results captured through the survey. The results chapter is broken into three sections with each reviewing a specific hierarchy used in the study: TMDL Informational Elements, Stakeholder Characteristics, and Management Options.

Comparison Element	Subquestion	Answers					Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored				
1	Numerical Data/Consultations	7 (54%)	4 (31%)	1 (8%)	0 (0%)	1 (8%)	13 (100%)	13	1.8	1.2
2	Numerical Data/Case Studies	6 (46%)	1 (8%)	4 (31%)	0 (0%)	2 (15%)	13 (100%)	13	2.3	1.5
3	Consultations/Case Studies	2 (15%)	1 (8%)	1 (8%)	6 (46%)	3 (23%)	13 (100%)	13	3.5	1.4

**Figure 7: Breakdown of IKA Survey Results**

Figure 7 details how each question is broken down with its relevant information. These tables are pulled directly from the IKA online survey service and show each question along with sub questions that contain each comparison choice. The first element listed is the option on the left while the second element listed is the right-side option. Answers are arranged based on this format with votes being tallied in a five point system: favored or slightly favored to one option, equal between the two options and favored and slightly favored to the other option. If the WQM rates the left option more than the right, the system places their vote in the left side of neutral. The opposite occurs for answers favoring the right-side option. Included are metrics downloaded from the IKA site: Valid, Units, Average, and Standard Deviation. Valid and Units show how many participants engaged in the sub question, with

Valid showing how many answered the question and Units showing how many accessed the question. The average is the calculated average value of the responses, with three being neutral; anything lower than three favors the left option and anything higher than three favors the right-side option. Standard Deviation is the variance of the responses for each sub question.

The last question of the survey asked respondents to review the three hierarchies in relation to successful TMDL completion. These responses are included in Table 4. Of the 13 respondents (Units), only 12 answered the question (Valid). As mentioned previously, the one respondent had not yet been exposed to the final elements of BMAP development and was unable to answer questions regarding the Management Options.

**Table 4: Question 17 Results from 1KA**

Q17	Taking into consideration all the elements that make up each section (TMDL Informational Elements, Stakeholder Characteristics, and Management Options) how would you rate each section in relation to the others?										
	Subquestion	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q17a	TMDL Information Elements/stakeholder characteristics	1 (8%)	4 (33%)	4 (33%)	2 (17%)	1 (8%)	12 (100%)	12	13	2.8	1.1
Q17b	TMDL Information Elements/ Management Options	1 (8%)	1 (8%)	6 (50%)	3 (25%)	1 (8%)	12 (100%)	12	13	3.2	1.0
Q17c	Stakeholder Characteristics/ Management Options	0 (0%)	1 (8%)	5 (42%)	4 (33%)	2 (17%)	12 (100%)	12	13	3.6	0.9

Overall, WQMs preferred TMDL Informational Elements to Stakeholder Characteristics with the majority of rankings being either equal or slightly in favor for Informational Elements. When compared to Management Options, both Stakeholder Characteristics and TMDL Informational Elements were seen as less favorable with Information being seen as greater in equality than Stakeholder Characteristics.

## 6.1: Survey Results for TMDL Informational Elements

This sections addresses elements used in constructing the TMDL equation, primarily data used to calculate the load limit and the waste allocations that WQMs must create a BMAP to manage. As shown in the Methodology section, the following hierarchy was constructed from the literature review (Chapter 2). The three main information elements used in the study are Numerical Data, Consultations, and Case Studies/Scientific Research. Each of these represents a potential source that contributes to calculating a TMDL. Under each element is a sub-category that breaks down the element further into researchable items for the study. These again, are broken down further to continue the investigation of the TMDL Informational Elements.

Questions 1 through 7 specifically asked WQMs to rank their preferences regarding data sources and research options. Question 1 asked WQMs to rank the three main data elements in relation to each other. Table 5 highlights WQMs choosing Numerical Data strongly over Consultations and Case Studies. Interestingly, Case studies ranked significantly higher than Consultations by comparison.

**Table 5: Question 1 Results from 1 KA**

Q1	Subquestion	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
	Of three information sources used in TMDL development (Numerical Data gathered by the DEP, Professional Consultations from outside organizations including other government branches and volunteer sources, and Case Studies/Scientific Research previously conducted on the WBID) what is your preference related to each?										
Q1a	Numerical Data/Consultations	7 (54%)	4 (31%)	1 (8%)	0 (0%)	1 (8%)	13 (100%)	13	13	1.8	1.2
Q1b	Numerical Data/Case Studies	6 (46%)	1 (8%)	4 (31%)	0 (0%)	2 (15%)	13 (100%)	13	13	2.3	1.5
Q1c	Consultations/Case Studies	2 (15%)	1 (8%)	1 (8%)	6 (46%)	3 (23%)	13 (100%)	13	13	3.5	1.4

Table 6 highlights Question 2, which asked WQMs to review a specific detail regarding Numerical Data gathered by the FDEP. This table illustrates that WQMs overwhelmingly preferred that data be collected from the Point of Impact or Source within



the WBID. Almost all respondents chose favored for point of impact data over referenced data from neighboring locations.

**Table 6: Question 2 Results from 1KA**

Q2	In regards to Numerical Data gathered by the DEP, what is your preference regarding how this data is derived from: point of impact/source or data that is referenced from neighboring WBIDs?										
	Subquestion	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q2a	Referenced Data/Point of Impact	1 (8%)	0 (0%)	0 (0%)	1 (8%)	11 (85%)	13 (100%)	13	13	4.6	1.1

Question 3 (Table 7) asked which method of data collection WQMs ranked highest for Referenced Data used in Numerical Data: Data collected by the FDEP department, contracted services or Volunteer group gathered information. Question 4 (Table 8) asked the same question but for Point of Impact/Source. Here you can see WQMs ranked Institutionally gathered data the highest option for both types of data, with Volunteer group data ranking last. This ranking could show WQMs disfavoring 3<sup>rd</sup> party derived data.

**Table 7: Question 3 Results from 1KA**

Q3	What is your preference regarding the source for Referenced data used in the TMDL development; derived from within the organization, volunteer group or obtained from an outside company/organization?										
	Subquestion	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q3a	Institutionally Derived/Volunteer Group	12 (92%)	1 (8%)	0 (0%)	0 (0%)	0 (0%)	13 (100%)	13	13	1.1	0.3
Q3b	Institutionally Derived/Contract	2 (15%)	3 (23%)	6 (46%)	0 (0%)	2 (15%)	13 (100%)	13	13	2.8	1.2
Q3c	Volunteer Group/Contract	0 (0%)	0 (0%)	1 (8%)	5 (38%)	7 (54%)	13 (100%)	13	13	4.5	0.7

**Table 8: Question 4 Results from 1KA**

Q4	What is your preference regarding the source for Point of impact/source data used in the TMDL development; derived from within the organization, volunteer group or obtained from an outside company/organization?										
	Subquestion	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q4a	Institutionally Derived/Volunteer	10 (77%)	3 (23%)	0 (0%)	0 (0%)	0 (0%)	13 (100%)	13	13	1.2	0.4
Q4b	Institutionally Derived/Contract	2 (15%)	4 (31%)	5 (38%)	0 (0%)	2 (15%)	13 (100%)	13	13	2.7	1.3
Q4c	Volunteer Group/Contract	0 (0%)	0 (0%)	1 (8%)	5 (38%)	7 (54%)	13 (100%)	13	13	4.5	0.7

Questions 5 and 6 are shown in Tables 9 and 10 and investigate WQMs tendencies in researching methodologies and WBIDs basin information. Both asked WQMs for their preference regarding researching either in a workshop/group setting or individually. For both questions, WQMs preferred to work in-group settings to gather information on basin sites and the final management plans. The idea of collaboration on developing the TMDL project is interesting as later questions highlight tendencies for WQMs to place less emphasis on collaboration from stakeholders.

**Table 9: Question 5 Results from 1KA**

Q5	How do you prefer to research information regarding the basin site: brainstorming with a group/workshop with other BMAP managers or Stakeholders, or as an individual researcher?										
	Subquestion	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q5a	Group Workshop/Self Research	4 (31%)	4 (31%)	2 (15%)	1 (8%)	2 (15%)	13 (100%)	13	13	2.5	1.5

**Table 10: Question 6 Results from 1KA**

Q6	How do you prefer to research information regarding basin management action plans: brainstorming with a group/workshop with other BMAP managers or Stakeholders, or as an individual researcher?										
	Subquestion	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q6a	Group Workshop/Self research	5 (38%)	4 (31%)	1 (8%)	2 (15%)	1 (8%)	13 (100%)	13	13	2.2	1.4

Question 7 is the last question in the TMDL Informational Elements hierarchy and asked WQMs which process, scientific literature or case studies, presents the most help. Managers ranked the development process slightly ahead of the implementation process. Table 11 highlights the condensed rankings for the question.

**Table 11: Question 7 Results from 1KA**

Q7	In which process is Case Studies/Scientific Literature most helpful for?										
	Subquestion	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q7a	Development Process/Implementation	2 (15%)	6 (46%)	2 (15%)	2 (15%)	1 (8%)	13 (100%)	13	13	2.5	1.2

## 6.2: Survey Results for Stakeholder Characteristics

The second hierarchy used in the study was Stakeholder Involvement Elements. Several components of stakeholder characteristics and involvement were broken down for investigation within the survey. WQMs were asked to rank Scientific Knowledge, Participation, and Feedback in specific processes, and lastly, the Knowledge Translation they preferred to educate the public. These components were broken down into sub-categories for further analysis, (Involvement/Characteristics: Scientific Knowledge, Feedback, and Participation). Table 12 details the results. WQMs preferred Scientific Knowledge to both Participation and Feedback, with feedback ranked slightly behind participation. This is particularly interesting given Questions 5 and 6 showing WQMs preferring to work as a group when developing their basin or BMAP.

**Table 12: Question 8 Results from 1KA**

Q8	Subquestion	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q8a	Scientific Knowledge/Participation	5 (38%)	3 (23%)	3 (23%)	2 (15%)	0 (0%)	13 (100%)	13	13	2.2	1.1
Q8b	Scientific Knowledge/Feedback	2 (15%)	5 (38%)	5 (38%)	1 (8%)	0 (0%)	13 (100%)	13	13	2.4	0.9
Q8c	Participation/Feedback	1 (8%)	4 (31%)	5 (38%)	3 (23%)	0 (0%)	13 (100%)	13	13	2.8	0.9

Question 9 investigated the previous question further by asking respondents to rank specific items in relation to Scientific Knowledge. Managers were asked their preferences on which Scientific Knowledge element from either understanding of Modeled Data, Data Acquisition by the FDEP, the BMAP implementation process, and the development of the TMDL was crucial for successful TMDL implementation. Table 13 shows that WQMs ranked Data Acquisition as the top characteristic with BMAP implementation process ranked second, TMDL development third, and knowledge of modeled data ranked last. This could be

denoting that understanding how all values have been obtained could be reducing the amount of kickback when a project is started.

**Table 13: Question 9 Results from 1KA**

Q9		Which related qualities are preferred in Stakeholder Scientific Knowledge: knowledge in Modeled Data, Data Acquisition, BMAP Implementation, or TMDL Development?									
Subquestion		Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q9a	Modeled Data/Data Acquisition	0 (0%)	0 (0%)	2 (15%)	4 (31%)	7 (54%)	13 (100%)	13	13	4.4	0.8
Q9b	BMAP Implementation/TMDL Development	1 (8%)	4 (31%)	4 (31%)	3 (23%)	1 (8%)	13 (100%)	13	13	2.9	1.1
Q9c	BMAP Implementation/ Modeled Data	1 (8%)	8 (62%)	2 (15%)	2 (15%)	0 (0%)	13 (100%)	13	13	2.4	0.9
Q9d	Modeled Data/TMDL Development	0 (0%)	4 (31%)	4 (31%)	5 (38%)	0 (0%)	13 (100%)	13	13	3.1	0.9
Q9e	BMAP Implementation/ Data Acquisition	1 (8%)	2 (15%)	4 (31%)	1 (8%)	5 (38%)	13 (100%)	13	13	3.5	1.4
Q9f	TMDL Development//Data Acquisition	0 (0%)	1 (8%)	4 (31%)	3 (23%)	5 (38%)	13 (100%)	13	13	3.9	1.0

Question 10 investigated the process managers preferred to have stakeholders be involved in, either the development process or the actual implementation of the action plan. The development process was ranked highest (Table 14). This ties in with Questions 5 and 6 showing again WQMs prefer involved collaboration in the planning process.

**Table 14: Question 10 Results from 1KA**

Q10		What is your preference for Stakeholder participation regarding the development process or the implementation process?									
Subquestion		Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q10a	Development Process/Implementation Process	2 (15%)	1 (8%)	8 (62%)	0 (0%)	2 (15%)	13 (100%)	13	13	2.9	1.2

The last question (11) in this section sought to analyze which method of education WQMs believed to have the most impact on educating the public on TMDL information and BMAP strategies. Table 15 shows workshops as the best medium to effectively relay information to the public with education programs (i.e. Printed materials and produced snippets sent out via mail or through the web) or Boundary Program (programs ran through universities or related institutions).

**Table 15: Question 11 Results from 1KA**

Q11	In your opinion which method is better for educating Stakeholders on the TMDL and BMAP Processes: Educational Programs though the internet or printed materials, Workshops sponsored by the water management district, or Boundary programs through different government departments or other related institutions, such as universities?	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q11a	Education Programs/ Workshops	0 (0%)	2 (15%)	2 (15%)	3 (23%)	6 (46%)	13 (100%)	13	13	4.0	1.2
Q11b	Boundary Programs/Workshops	0 (0%)	0 (0%)	4 (31%)	6 (46%)	3 (23%)	13 (100%)	13	13	3.9	0.8
Q11c	Boundary Programs/Education Programs	1 (8%)	3 (23%)	4 (31%)	5 (38%)	0 (0%)	13 (100%)	13	13	3.0	1.0

### **6.3: Survey Results for Management Options**

The last hierarchy concerns the Management Options available to WQMs to create effective BMAPs. Respondents ranked controls on Point, Non-point, Habitat Modification, and Clean-up/Removal efforts by the department and stakeholders. These elements were further complied with specific functions to help differentiate possible control solutions.

Table 16 highlights the results for Question 12, which asked WQMs to give their preference for the four main controls in the hierarchy: Point, Non-point, Habitat Modification, and Clean-up/removal. Respondents showed a slight preference for Point source controls ahead of Non-point controls. Both Point and Non-point are ranked higher than Habitat Modification and Clean-up/Removal.

**Table 16: Question 12 Results from 1KA**

Q12	What is your preference related to these Management Options: Habitat Modification (buffer zones, restoration, etc.), Non-Point Source Controls (Structural or Non-Structural BMPs), Point Source Controls (Structural controls such as mandated process improvements or infrastructure upgrades; or Non-Structural methods such as permitting increases on NPDES and MS4s), or Cleanup/Removal activities (dredging/ brownfield site restoration)?										
	Subquestion	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q12a	Point Source Controls/Non-Point Source Controls	3 (25%)	0 (0%)	7 (58%)	1 (8%)	1 (8%)	12 (100%)	12	13	2.8	1.2
Q12b	Point Source Controls/Habitat Modification	3 (25%)	2 (17%)	4 (33%)	1 (8%)	2 (17%)	12 (100%)	12	13	2.8	1.4
Q12c	Point Source Controls/Clean up	3 (25%)	0 (0%)	7 (58%)	2 (17%)	0 (0%)	12 (100%)	12	13	2.7	1.1
Q12d	Habitat Modification/Non-Point Source Controls	1 (8%)	1 (8%)	4 (33%)	4 (33%)	2 (17%)	12 (100%)	12	13	3.4	1.2
Q12e	Non-Point Source Controls/Clean up	2 (17%)	3 (25%)	5 (42%)	1 (8%)	1 (8%)	12 (100%)	12	13	2.7	1.2
Q12f	Habitat Modification/Clean up	1 (8%)	1 (8%)	7 (58%)	3 (25%)	0 (0%)	12 (100%)	12	13	3.0	0.9

Question 13 (Table 17) asked respondents to rank structural methods versus non-structural for Point source controls. Structural controls are defined as mandated process improvements and infrastructure upgrades while non-structural controls are listed as permits for NPDES and MS4s. WQMs preferred to use these structural controls rather than the nonstructural controls.

**Table 17: Question 13 Results from 1KA**

Q13	In regards to Point Source Controls which do you believe to have the most impact or to be the most effective? Structural controls such as mandated process improvements or infrastructure upgrades; or Non-Structural methods such as permitting increases on NPDES and MS4s?										
	Subquestion	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q13a	Structural/Nonstructural	5 (42%)	5 (42%)	0 (0%)	2 (17%)	0 (0%)	12 (100%)	12	13	1.9	1.1

Question 14 asked WQMs to rank Agricultural BMPs in relation to Urban BMPs according to effectiveness. Interestingly, Table 18 shows WQMs stating Urban BMPs as more effective than Agricultural controls.

**Table 18: Question 14 Results from 1KA**

Q14	With Non-Point Source Controls which is the most effective?										
	Subquestion	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q14a	Agricultural BMPs/Urban BMPs	1 (8%)	0 (0%)	5 (42%)	3 (25%)	3 (25%)	12 (100%)	12	13	3.6	1.2

Questions 15 and 16 investigate both components of Question 14, asking WQMs preference for Structural or Nonstructural Controls in each Agricultural (Question 15, Table 19) and Urban BMPs (Question 16, Table 20). In the Urban scenario, WQMs ranked Structural controls over Non-structural controls, with the opposite being observed for Agricultural controls where Non-structural controls were seen as more effective. This can be inferred as an explanation for the ranking over urban BMPs over agricultural BMPs since structural controls offer easier inspection and enforcement.

**Table 19: Question 15 Results from 1KA**

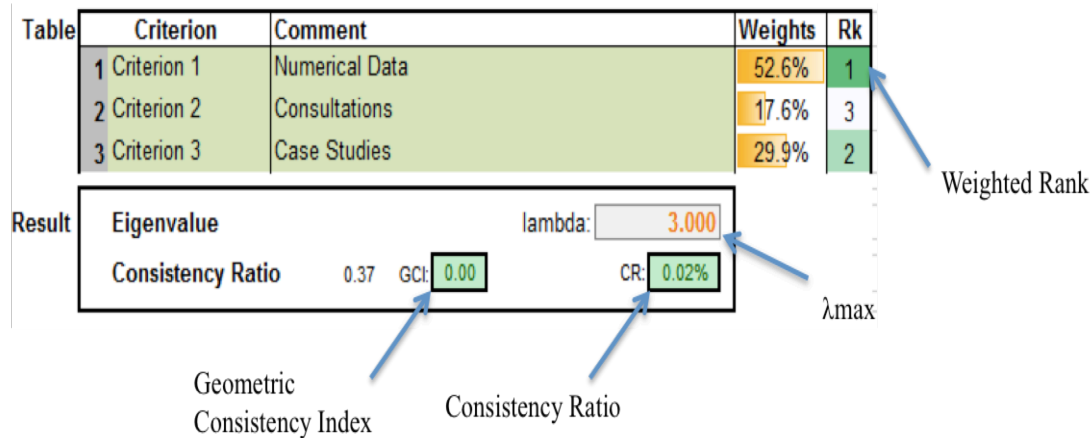
Q15	In relation to Agricultural BMPs which are you preference Structural controls (Land Modification, structural improvements i.e. water control devices, fencing etc.) or Non-Structural (regulation on irrigation, nutrients, etc. or permitting changes)?										
	Subquestion	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q15a	Structural/Nonstructural	2 (17%)	0 (0%)	4 (33%)	3 (25%)	3 (25%)	12 (100%)	12	13	3.4	1.4

**Table 20: Question 16 Results from 1KA**

Q16	In relation to Urban BMPs which are your preference Structural controls (upgrades to infrastructure, wastewater upgrades, storm water collection, etc.) or Non-Structural (Ordinance changes, permitting management, regulation of fertilizers, etc.)?										
	Subquestion	Answers						Valid	Units	Average	Std. deviation
		Favored	Slightly Favored	Equal	Slightly Favored	Favored	Valid				
Q16a	Structural/Nonstructural	3 (25%)	3 (25%)	3 (25%)	2 (17%)	1 (8%)	12 (100%)	12	13	2.6	1.3

## CHAPTER 7: DISCUSSION

In this section we will review the analyzed results of the survey. The following tables used in this discussion detail the Geometric Consistency Index, Consistency Ratio, the  $\lambda_{max}$ , and the final ranking based off the weighted results from the survey. Figure 8 provides a breakdown on the components that make up each table. The final ranking for the question is shown in the Weighted Rank on the right side of the table.



**Figure 8: Breakdown of Tabled Statistical Analysis**

### 7.1: Analysis of Findings

We examined the research questions previously stated in Chapter 4: Research Design along with further analysis of sub-questions based on the components of successful TMDL implementation. The first research problem questioned if WQMs would favor more direct data rather than "modeled" or periodical information, with the largest preference for previous case studies/examples within TMDL cases. Table 21 examines the results from Question 2



where WQMs were asked for their preference regarding data being from the location concerning the TMDL or referenced data from neighboring WBIDs.

**Table 21: Question 2 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Referenced Data	21.0%	2
2	Criterion 2	Point of Impact/Source	78.9%	1

Result	Eigenvalue	lambda: 1.999		
	Consistency Ratio	0.37	GCI: n/a	CR: 0.08%

WQMs preferred that data be sourced from the point of impact with a small CR, which shows a strong relationship or the majority siding with this preference. The second component of this research problem questioned the source of data from either numerical data gathered specifically for TMDL development, consultations by nongovernment organizations, or case studies/scientific literature concerning the WBID in question. Table 22 shows the calculated results from Question 1, which asked WQMs to rank these sources in relation to each other.

**Table 22: Question 1 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Numerical Data	52.6%	1
2	Criterion 2	Consultations	17.6%	3
3	Criterion 3	Case Studies	29.9%	2

Result	Eigenvalue	lambda: 3.000		
	Consistency Ratio	0.37	GCI: 0.00	CR: 0.02%

Preference is strongly in favor for data specifically collected by the FDEP for the particular TMDL in question. Case studies ranked second; this ranking shows a preference for current data rather than third party validated numbers. This point is further emphasized in the ranking of consultations as third, possibly showing distrust or unease with using data collected outside of the FDEP or county government. Having data modeled from nearby points or watersheds was seen as suboptimal for creating a complete and effective BMAP. Further analyzing this data, respondents were asked to rank information sources and the specifics

regarding each choice. WQMs ranked data coming from within their organizations at the county and state level as the preferred reference for data, no matter the data type. Table 23 refers to data taken from the point of impact/source, and Table 24 shows data modeled from nearby WBIDs.

Point of impact/source:

**Table 23: Question 4 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Institutionally Derived	50.8%	1
2	Criterion 2	Volunteer Group	11.4%	3
3	Criterion 3	Contractually Derived	37.9%	2

<b>Result</b>	<b>Eigenvalue</b>		lambda:	3.002
	<b>Consistency Ratio</b>	0.37	GCI:	0.01
			CR:	0.21%

Referenced:

**Table 24: Question 3 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Institutionally Derived	50.3%	1
2	Criterion 2	Volunteer Group	11.0%	3
3	Criterion 3	Contractually Derived	38.7%	2

<b>Result</b>	<b>Eigenvalue</b>		lambda:	3.000
	<b>Consistency Ratio</b>	0.37	GCI:	0.00
			CR:	0.01%

Volunteer groups being negatively ranked for data collection offers insight on WQMs preference regarding credibility in data collection. While not extensively, FDEP consults volunteer groups on collecting and analyzing data. Question 3's data shows that WQMs prefer data collected internally possibly due to perceived inadequacies in data collection, especially when data is scrutinized in court for TMDL challenges. The challenges of incorporating differing data sets are common in environmental management (Raymond et al., 2010). A separate department from WQMs handles the FDEP's data collection, so this may represent a gap in TMDL understanding. Prospective studies should challenge on what it is about volunteer data that is less desirable than data from the department or provided through

contracted services. Clarifying this will help the state properly convey data collection methodologies at a county level. The literature review has shown that proper and frequent data collection activities improves the assignment of load allocations which can help improve the TMDL process (Miao et al., 2016) Questions 5 and 6 asked WQMs to gauge how they prefer to research basin sites (Table 25) and comparative BMAPs (Table 26). WQMs preferred working in a group setting to complete information regarding both basin sites and the action plans to effectively manage impairments.

Basin site:

**Table 25: Question 5 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Group Workshop	62.2%	1
2	Criterion 2	Self-Research	37.7%	2

<b>Result</b>	<b>Eigenvalue</b>		lambda:	1.999
	<b>Consistency Ratio</b>	0.37	GCI:	n/a
			CR:	0.11%

Basin management action plan:

**Table 26: Question 6 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Group Workshop	64.1%	1
2	Criterion 2	Self-Research	35.9%	2

<b>Result</b>	<b>Eigenvalue</b>		lambda:	1.999
	<b>Consistency Ratio</b>	0.37	GCI:	n/a
			CR:	0.11%

Lastly, in this line of questioning, WQMs were asked their opinion regarding what stage (the development process or the implementation process) was using case studies and academic literature the most helpful. Question 7's results are shown in Table 27 and illustrate that case studies are seen as most helpful during the development process. The development process is where managers create the final action plan, representing a final checkpoint. Once approved, the plan is approved into the Florida Statute (Hueber, 2010). In future studies, this question should be elaborated to detail what process case studies can impact the most in the

development process, either implementing BMAPs or development plans in the TMDL process.

**Table 27: Question 7 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Development Process	61.3%	1
2	Criterion 2	Implementation Process	38.6%	2

Result	Eigenvalue	lambda: 1.999		
	Consistency Ratio	0.37	GCI: n/a	CR: 0.11%

The second research problem states that stakeholder knowledge translation will be a key component to BAP success and Scientific arguments its largest sub-factor. Question 17 asked WQMs to rank the three components to TMDL implementation; Table 28 highlights these rankings.

**Table 28: Question 17 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	TMDLInformation Elements	32.8%	2
2	Criterion 2	Stakeholder Characteristics	26.2%	3
3	Criterion 3	Management Options	41.0%	1

Result	Eigenvalue	lambda: 3.003		
	Consistency Ratio	0.37	GCI: 0.01	CR: 0.31%

As shown, managers ranked management options slightly ahead of other components, with stakeholder characteristics ranking third. The consistency ranking shows a value of 0.31%, which denotes the majority of rankings have no strong placement, but rather “softer” placements. Given the multifaceted approach needed for BMAP development, this would be practical as each component has a place in the process. The CR also signifies this question’s responses as not completely random, so the answers remain valid. Having strong management options logically has the benefits of ensuring TMDL completion and produces presentable results. This is still reliant on proper TMDL data, ranked second in the matrix. With placing Stakeholder Characteristics third, the rankings highlight an emphasis placed on

the previous components over involvement. While WQMs do not argue their importance, objectively, the support of the community or its involvement is secondary to accurate data and proper management plans. According to the literature, this ranking indicates disillusionment has grown amongst practitioners who have felt let down that claimed benefits of stakeholder participation are not realized (Reed, 2008). Given the task of coordinating with the public on a huge environmental project, it is possible the FDEP needs to invest more time and training to fully engage their WQMs with stakeholder facilitation. Question 8 asked WQMs which trait in stakeholder characteristics they viewed as most beneficial to the TMDL process. Table 29 displays the final rankings from the WQMs.

**Table 29: Question 8 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Scientific Knowledge	48.8%	1
2	Criterion 2	Feedback	26.9%	2
3	Criterion 3	Participation	24.3%	3

<b>Result</b>	<b>Eigenvalue</b>	lambda:	3.012
	<b>Consistency Ratio</b>	0.37 GCI:	0.04 CR: 1.23%

In regards to stakeholder characteristics, respondents preferred that stakeholders have scientific knowledge over responsive feedback and even participation, confirming the concurrent part of the second research problem. This question should be explored more fully to understand why this preference occurs. WQMs may be signaling that having an educated audience that knows the process and its importance has a greater impact than the other qualities. It should be noted that this question has the highest CR of the survey. It still falls within limits but shows softer rankings by WQMs with some possible equality between the factors. Questions 9, 10, and 11 analyzed aspects of the stakeholder characteristics element. Question 9 builds on the scientific knowledge preference, asking managers to rank specific items that they wished stakeholders had previous knowledge of. Table 30 shows that knowledge regarding how TMDLs source and compile their data was seen as the most

important aspect of scientific knowledge (over how data is modeled, a TMDL is developed, or the BMAP is implemented). This may reference stakeholders having doubts regarding a final TMDL's calculations and thus a benefit of this quality would be that stakeholders would be more trusting of the final adjustments.

**Table 30: Question 9 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Modeled Data	14.9%	4
2	Criterion 2	Data Acquisition	42.2%	1
3	Criterion 3	BMAP Implementation	23.9%	2
4	Criterion 4	TMDL Development	19.0%	3

Result	Eigenvalue	lambda: 4.025		
	Consistency Ratio	0.37	GCI: 0.03	CR: 0.90%

Question 10 asked WQMs to rank the phase most desirable for stakeholder participation in the TMDL process. Respondents preferred stakeholders to be involved in the development process to the implementation process, shown in Table 31. Given the complex dynamics of creating a BMAP, WQMs believe that having stakeholders actively participating in the development process ensured successful TMDL implementation, as participants were active in the final development and thus part of the ultimate decision.

**Table 31: Question 10 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Development Process	52.1%	1
2	Criterion 2	Implementation Process	47.9%	2

Result	Eigenvalue	lambda: 1.999		
	Consistency Ratio	0.37	GCI: n/a	CR: 0.12%

In BMAP implementation, those designated as responsible parties are required to comply with TMDL completion. While these parties are stakeholders, not all stakeholders would be considered responsible for implementation, which is why WQMs see this external input as possibly detrimental as commitment and expertise regarding the implementation activity could vary drastically. Responsible parties are liable for completing TMDL tasks and

related to their particular impairment source, thus they have a commitment and knowledge regarding the follow through. Previous research has found that with limited participation in planning, there is less of a chance for promoting learning and behavior change which is detrimental to program resilience and adaptability (Kirchhoff & Dilling, 2016). The last question of the section (Question 11) asked WQMs which education tool they recommended to properly inform stakeholders. Table 32 aggregated that in-person workshops were seen as the optimal method of conveying TMDL information and educating on the processes involved.

**Table 32: Question 11 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Education Programs	23.6%	2
2	Criterion 2	Boundary Programs	22.5%	3
3	Criterion 3	Workshops	54.0%	1

<b>Result</b>	<b>Eigenvalue</b>		lambda:	3.000
	<b>Consistency Ratio</b>	0.37	GCI:	0.00
			CR:	0.00%

The FDEP has used workshops extensively to inform the public on changes to TMDL legislature and regularly holds workshops for TMDL planning and implementation stages, so this data confirms that this active form of education is the correct course. It should be noted that the CR and GCI of this matrix are zero, highlighting the consistent ranking and clear options. According to the literature, there are limited opportunities for local or water management district planning to promote ongoing policy learning and change at the state level (Kirchhoff & Dilling, 2016) and the survey findings show a possible avenue for the DEP to strengthen community outreach

The last research problem argues that agricultural non-point related BMAPs would be the most relied on management method. Reviewing the management option section of the survey, Question 12 asked respondents to rank management options. Of the four options, WQMs had mixed and soft rankings on which deemed more favorable. Highlighted in Table

33, we see point source controls slightly ahead of non-point, habitat modification and cleanup/removal.

**Table 33: Question 12 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Point Source Controls	28.7%	1
2	Criterion 2	Nonpoint Source Controls	27.0%	2
3	Criterion 3	Habitat Modification	22.1%	4
4	Criterion 4	Clean-up	22.2%	3

Result	Eigenvalue	lambda: 4.007		
	Consistency Ratio	0.37	GCI: 0.01	CR: 0.25%

Both the GCI and CR were within limits, despite the soft rankings. Habitat modification and clean-up were ranked as predominately equal. Respondents were further asked to define which type of point source control was preferred. The data in Table 34 shows that structural controls were deemed most favorable in this comparison as they provided the most enforceable action to elicit results.

**Table 34: Question 13 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Structural	70.5%	1
2	Criterion 2	Non-structural	29.5%	2

Result	Eigenvalue	lambda: 1.999		
	Consistency Ratio	0.37	GCI: n/a	CR: 0.10%

Respondents were asked about non-point controls; rankings interestingly showed that urban BMPs were ahead of agricultural BMPs in effectiveness. Question 14 had WQMs rank these two elements, asking which selection was more effective. Table 35 highlights urban BMPs as the more effective option with CR of 0.11% showing "soft ranking" rather than strong favorability.



**Table 35: Question 14 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Agricultural BMPs	36.8%	2
2	Criterion 2	Urban BMPs	63.2%	1

Result	Eigenvalue	lambda: 1.999		
	Consistency Ratio	0.37	GCI: n/a	CR: 0.11%

With this analysis, it should be noted that the question fails to actually probe which option is the most relied on factor. Future studies need to investigate this gap by asking WQMs to show which management option is common in their BMAP development. Given the literature denoting agricultural runoffs effects on nutrient influx in terrestrial and marine water sources, the importance on urban runoff would be expected to be secondary in importance. Theoretically, urban non-point source controls being ranked higher in effectiveness represents the difficulty of enforcing and assigning TMDL sources with agriculture while simultaneously presenting urban runoff as an easier source to manage from the context of TMDL processes and legislative enforcement. Questions 15 and 16 detailed whether structural or non-structural controls were preferred for agricultural and urban BMPs. Table 36 details agricultural BMPs where non-structural elements are preferred, showing WQMs want legislation on irrigation and nutrient allowances while enforcing permits for polluters as denoted in the question.

**Table 36: Question 15 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Structural	40.7%	2
2	Criterion 2	Non-structural	59.3%	1

Result	Eigenvalue	lambda: 1.999		
	Consistency Ratio	0.37	GCI: n/a	CR: 0.12%

With urban BMPs, structural controls are valued more than nonstructural (ordinance, permitting, and regulations). Table 37 highlights results showing that in urban environments

point sources, such as wastewater collection, infrastructure, and stormwater, are seen as the main components contributing to a basins impairment load.

**Table 37: Question 16 Statistical Analysis**

Table	Criterion	Comment	Weights	Rk
1	Criterion 1	Structural	58.2%	1
2	Criterion 2	Non-structural	41.8%	2

<b>Result</b>	<b>Eigenvalue</b>	lambda:	1.999
	<b>Consistency Ratio</b>	0.37	GCI: n/a
			CR: 0.12%

This helps to reinforce the previous implications that urban BMPs represent the more successful of the two, thanks in part to the ability of WQMs to actively enforce and inspect urban structural controls. With Florida’s secretarial order and Florida Statute 403.067(7)(b) 2.h enforcement, measures are present, but as suggested in literature (Hueber, 2010), this method still has complications in enforcing and producing results. Ultimately, WQMs highlighted the emphasis that still pervades TMDL work that nonpoint source controls represent a more challenging management option and further work is needed to adequately control impairment loads.

Reviewing the research question from Chapter 4: Research Design, we find that managers use a framework of easily implemented controls that offer the most accurate accountability and tracking along with the easiest enforceability to meet water quality goals. This shows the most successful elements of the process in controlling point sources and easily identifiable impairment loads while diffusing non-point sources in rural areas where tracking and enforceability remain challenging. Nutrient loads still appear as the biggest obstacle for WQMs, despite advancements in enforceability. At the most basic level, the study offers a few critiques that should aid in helping the TMDL program advance. Strong public outreach and education along with increased transparency on data collection and processing represent significant value to helping furthering the TMDL objectives.

## **CHAPTER 8:**

### **CONCLUSION**

Water quality management requires a multifaceted approach to achieve success. Manager must be actively involved in both a technical aspect as a source of authority in addition to being flexible and responsive from a public outlook. The study shows WQMs look to access both these traits in a manner that gives reviewable and defensible results. Using AHP offers public policy insight that can help clarify obstacles from a ground level by understanding the priorities policy facilitators embrace. Previous work in the field of TMDL analysis has helped shape state programs by focusing on facets of data monitoring and modeling, BMP improvements and the importance of strong stakeholder commitments. Knowing how to translate these factions to project facilitators still represents where significant progress can be made. In relation to this knowing what facilitators need and want from the program allows program administrators to know what areas to address. This chapter will review the findings and implications from the analyzed survey data and then discuss the limitations encountered and possible avenues for further study.

#### **8.1: Findings and Policy Implications**

Three interesting components derived from the study present the biggest findings produced by the survey. The opinion that urban BMPs were more effective than agriculture BMPs show the challenge WQMs have in regards to reining in agriculture runoff. Resources are needed to make impactful change on how WQMs can effectively

curtail impairments on watersheds. Knowing that WQMs prefer stakeholders to have good scientific knowledge shows the importance that workshops and education programs have on successful TMDL implementation. Lastly, if volunteer-derived data is incorporated, the FDEP must continue to effectively vet this incoming data and properly inform its county level WQMs to ensure proper communication is established to relay that volunteer data used in cases can carry the same weight as institutionally derived data.

Florida represents a useful study in managing state water quality controls. The state has evolved the barebones policy of the Clean Water Act and has shown several quality functions on how to manage TMDL development. The use of enforceable action is particularly important, as this is the second most important hurdle TMDL programs must conquer, with funding being the forefront issue. Policy makers can adapt the results of this study to help mold legislation to equip WQMs with the tools necessary to meet quality standards and produce successful TMDL programs. Additional weight needs to be emphasized in streamlining data collection and the enforcement of non-point source BMPs.

## **8.2: Limitations and Future Studies**

A few limitations should be considered in this study, the first being time. WQMs are extremely busy, so efforts should be maintained to focus on providing support and response quickly to ensure the survey process doesn't complicate the routines of WQMs. Another factor is funding; currently, there is no funding for this project so choice regarding delivery of survey and interviews were constricted. The final limitation affecting this project was the scope of the questions. These factors were developed with expert input along with the literature review but are not an exhaustive list. The work is also predominately qualitative in nature; that approach carries the possibility of errors or bias.

An extra interview session to question respondents face-to-face has the potential to show greater detail on the survey question. A follow up with the respondents would prove helpful in curtailing the survey to produce clearer, greater information.

The questions on stakeholder involvement, emphasis on urban BMPs, use of scientific literature, and use of volunteer derived data should be elaborated and emphasized in prospective studies. Expanding these lines of questioning offer insight on these important aspects embedded in the TMDL process. The strength of this type of survey is its ability to allow researchers to crowd source ideas with experts and test potential improvements to the process; this needs to be expanded in future studies in TMDL process.

### **8.3: Summary**

Ultimately, this research represents a backbone of development into understanding which pieces of information, which alternatives best suit WQMs, and which offers the most incentive to policy makers. It is hoped that this data establishes a baseline for future work within decision making analysis in water quality management and, hopefully, spread its use in surrounding, related areas. The flexibility and engagement of this type of survey allows the researcher the ability to crowd source ideas with experts and test potential improvements to the process, which has impactful implications in a wide range of policy work. Policy administrators and legislators should look to give managers more outlets for public outreach to help inform the public. Helping to strengthen the scientific knowledge of the community will help aid policy implementation and improve informed stakeholder involvement. Managers also need clear and properly vetted data from the FDEP to help WQMs defend load allocations and properly plan their BMAPs. Lastly, policy needs to have defensible and appropriate enforcement mechanisms, which need to be properly funded for completion and sustainable reevaluations.

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## APPENDICES

## Appendix A: Water Quality Manager Survey with 9-point comparison

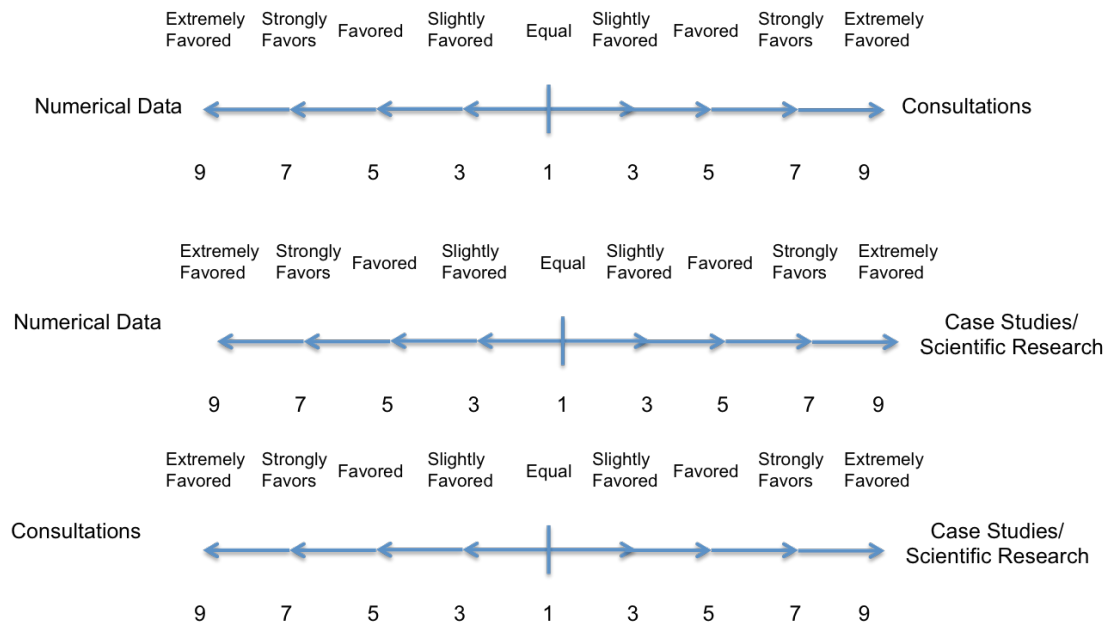
### WATER QUALITY MANAGER QUESTIONNAIRE

Below are several pair-wise comparison questions related to several elements of TMDL and BMAP creation including: TMDL Information usage, Stakeholder characteristics, and Management Options. Please mark your preference on the scale between the two options and if you have any comments or wish to add to your choices please use the comments box below the question.

#### **TMDL and BMAP Information Elements**

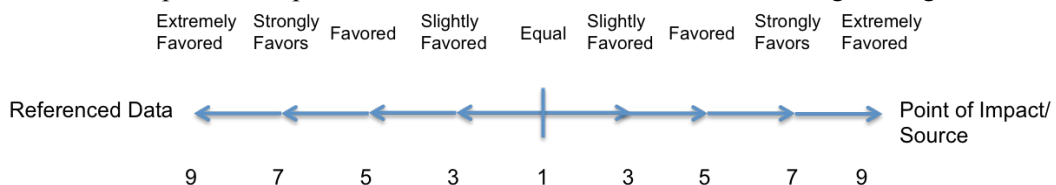
This section will refer to the finished TMDL Document received from the FDEP. The questions will deal with the elements that compose the TMDL and what elements are preferred to create proper and impactful BMAPs.

1. Of three information sources used in TMDL development (Numerical Data gathered by the DEP, Professional Consultations from outside organizations including other government branches and volunteer sources, and Case Studies/Scientific Research previously conducted on the WBID) what is your preference related to each?



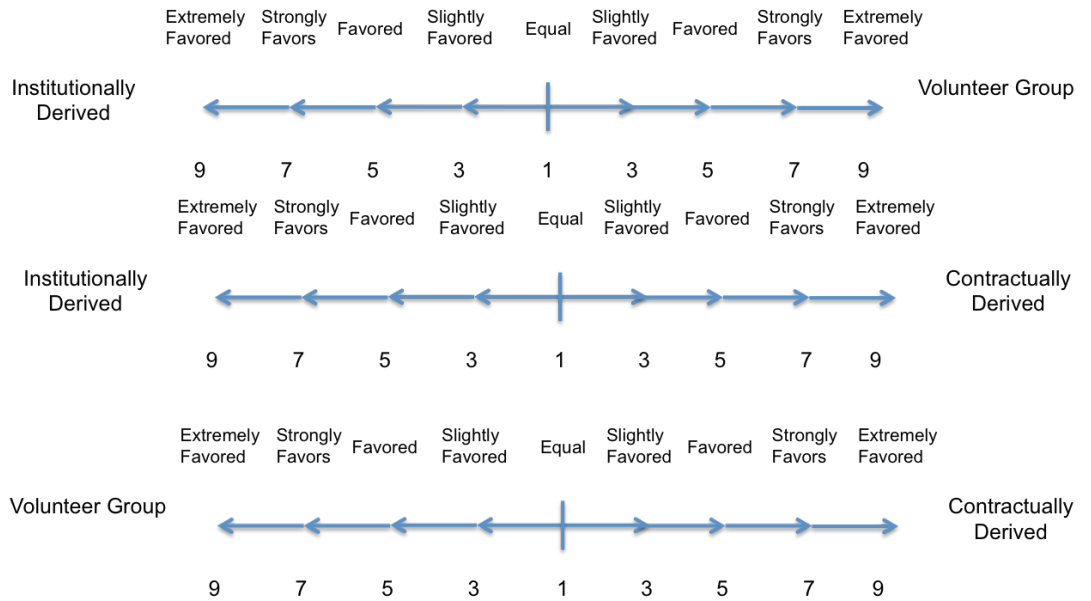
Comments:

2. In regards to Numerical Data gathered by the DEP, what is your preference regarding how this data is derived from: point of impact/source or data that is referenced from neighboring WBIDs?



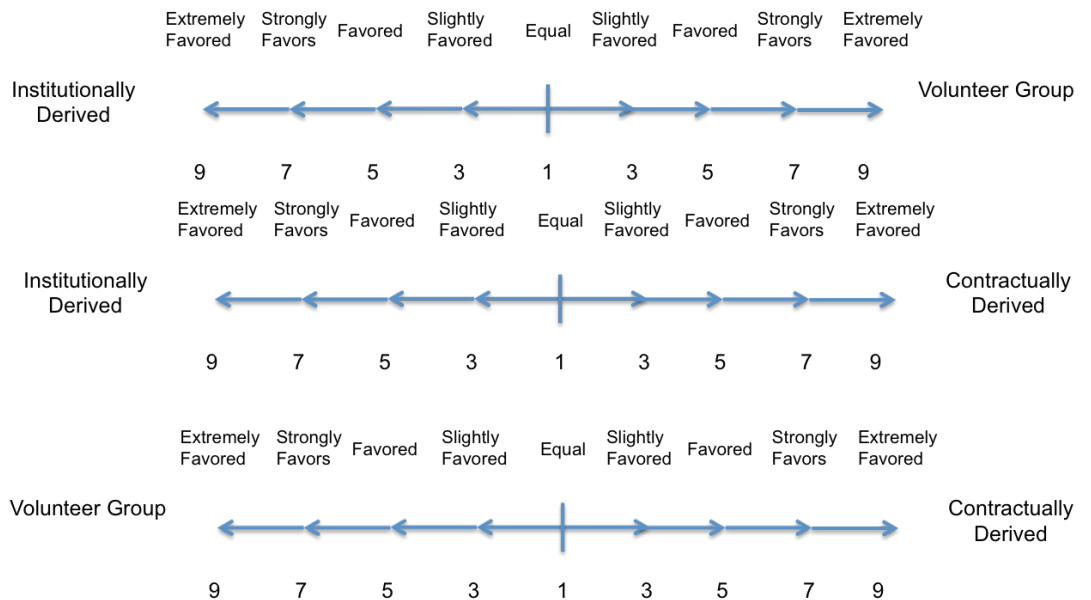
Comments:

3. What is your preference regarding the source for Referenced data used in the TMDL development; derived from within the organization, volunteer group or obtained from an outside company/organization?



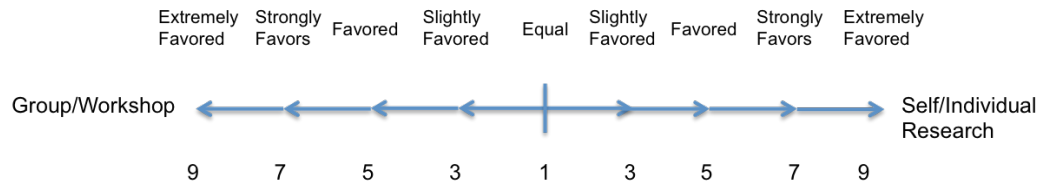
Comments:

4. What is your preference regarding the source for Point of impact/source data used in the TMDL development; derived from within the organization, volunteer group or obtained from an outside company/organization?



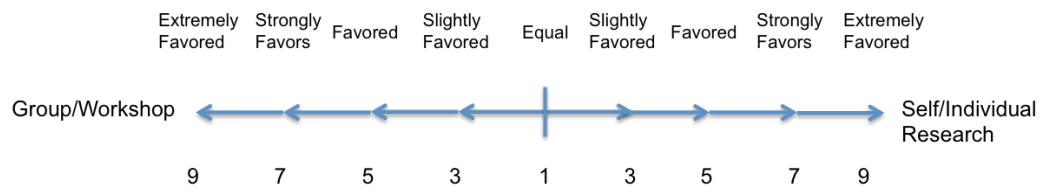
Comments:

5. How do you prefer to research information regarding the basin site: brainstorming with a group/workshop with other BMAP managers or Stakeholders, or as an individual researcher?



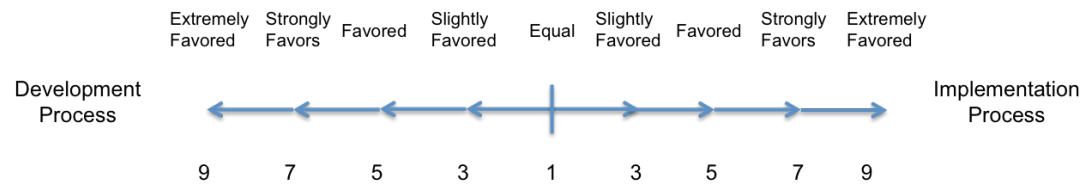
Comments:

6. How do you prefer to research information regarding basin management action plans: brainstorming with a group/workshop with other BMAP managers or Stakeholders, or as an individual researcher?



Comments:

7. In which process is Case Studies/Scientific Literature most helpful for?

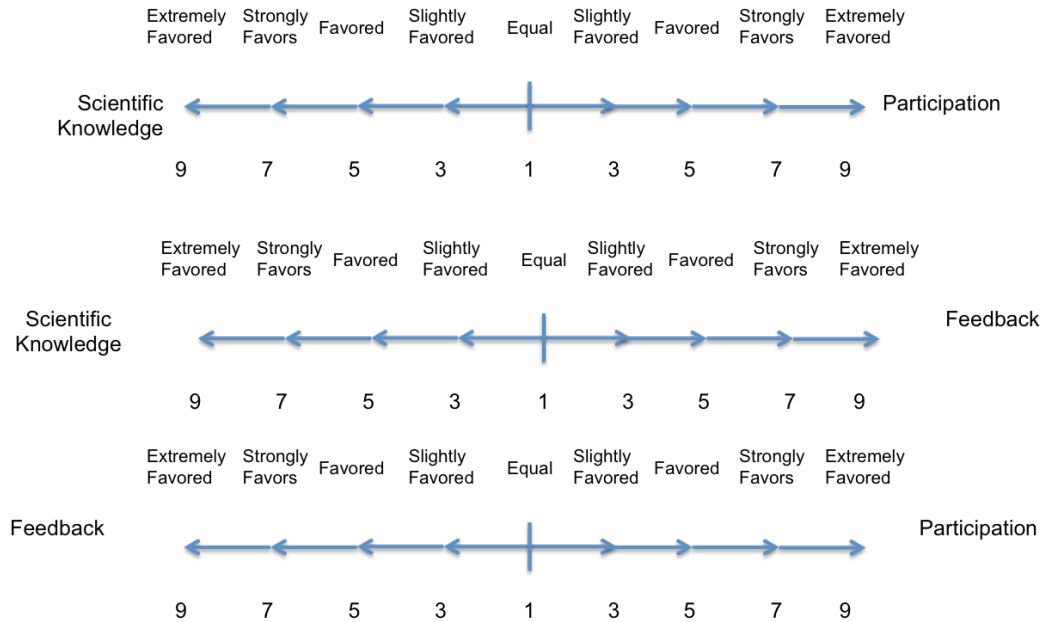


Comments:

**Stakeholder Characteristics Elements**

This section will ask you to rank your preferences regarding qualities in stakeholder that you find helpful in the development and implementation process.

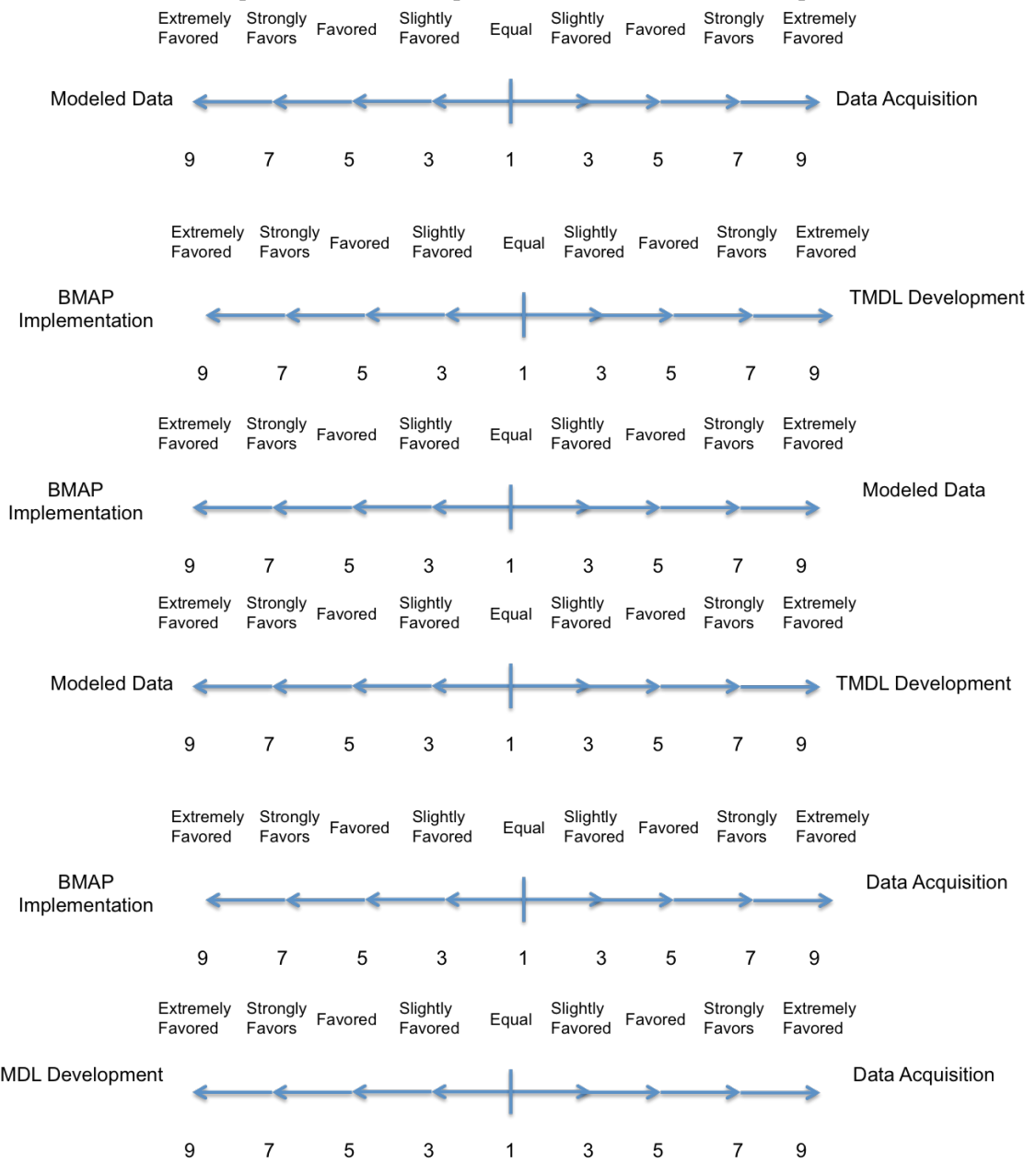
8. What are your rankings regarding these three traits of Stakeholder characteristics: Scientific Knowledge regarding the TMDL process and water quality impairments, Feedback in creation of BMPs and basin information, and Participation with the implementation process?



Comments:

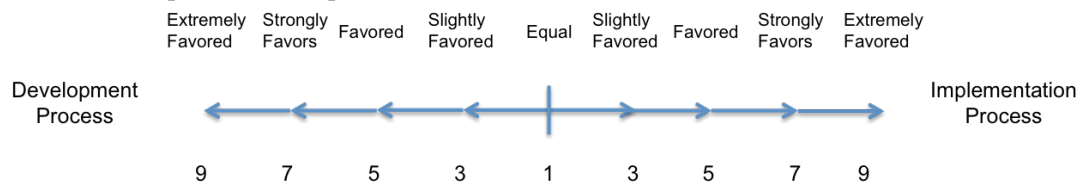


9. Which related qualities are preferred in Stakeholder Scientific Knowledge: knowledge in Modeled Data, Data Acquisition, BMAP Implementation, or TMDL Development?



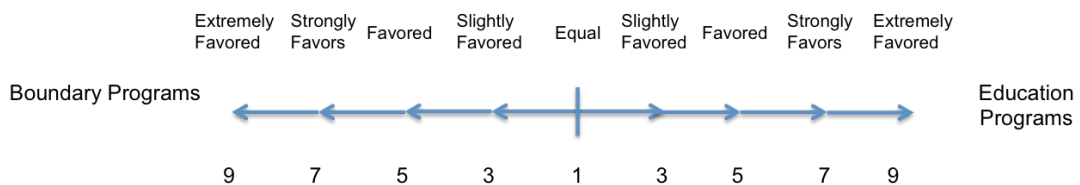
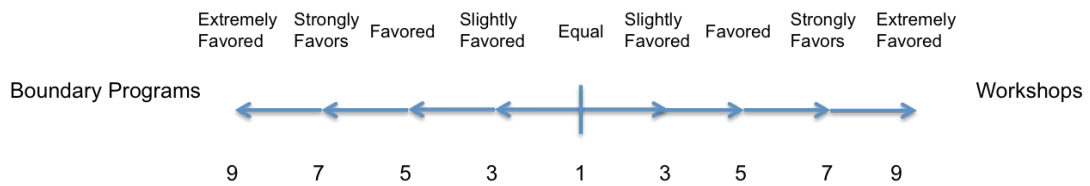
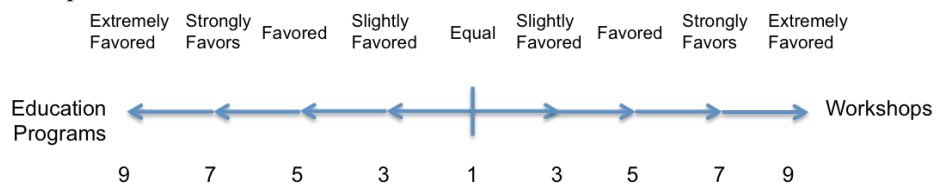
Comments:

10. What is your preference for Stakeholder participation regarding the BMAP development process or the implementation process?



Comments:

11. In your opinion which method is better for educating Stakeholders on the TMDL and BMAP Processes: Educational Programs though the internet or printed materials, Workshops sponsored by the water management district, or Boundary programs through different government departments or other related institutions, such as universities?

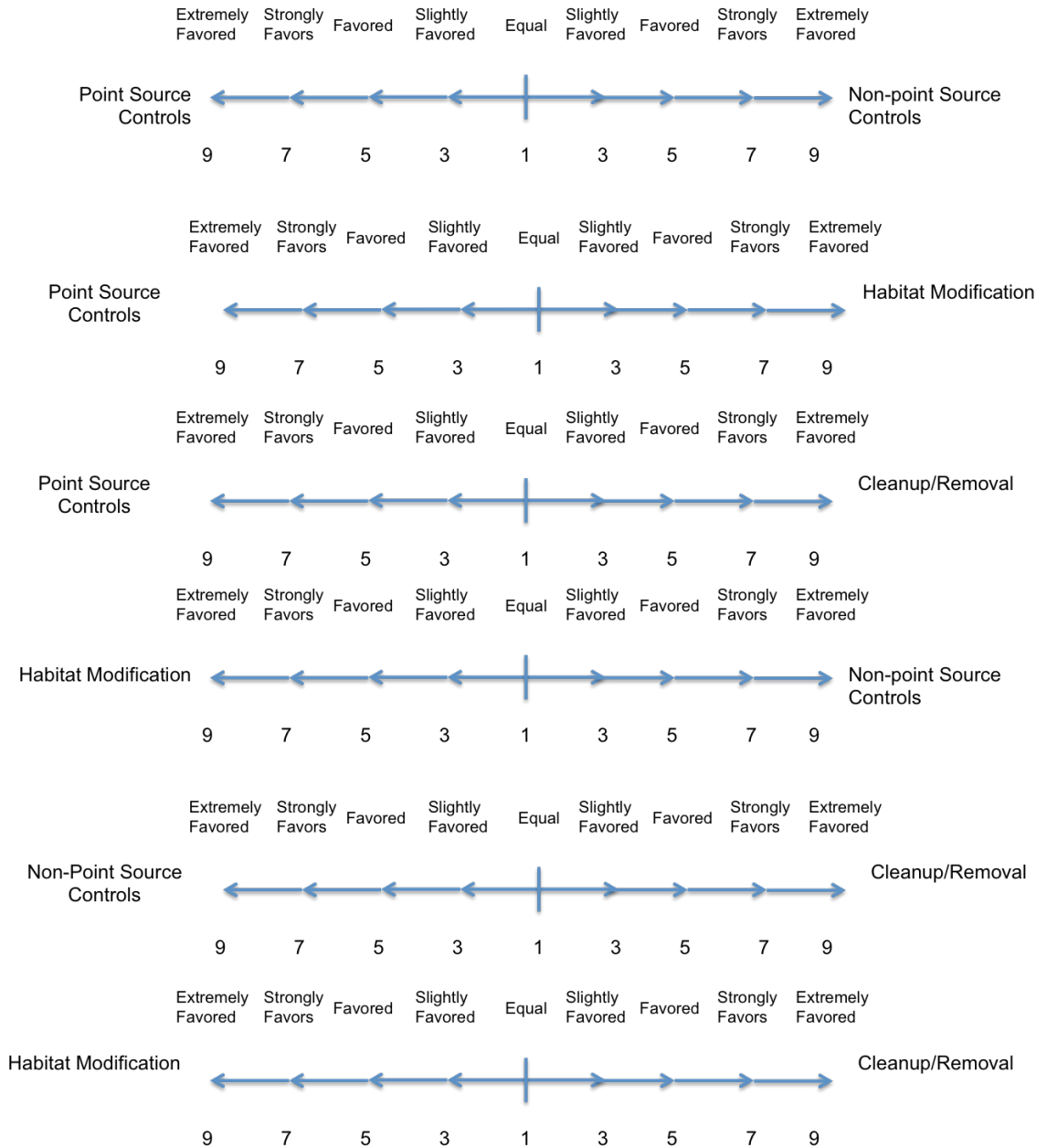


Comments:

**Management Options Elements**

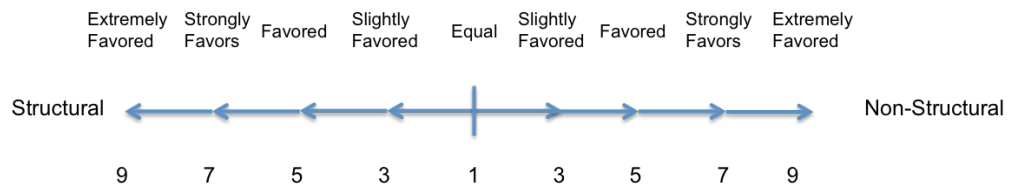
These elements deal with the options present for BMAP managers to use in achieving water quality goals

12. What is your preference related to these Management Options: Habitat Modification (buffer zones, restoration, etc.), Non-Point Source Controls (Structural or Non-Structural BMPs), Point Source Controls (Structural controls such as mandated process improvements or infrastructure upgrades; or Non-Structural methods such as permitting increases on NPDES and MS4s), or Cleanup/Removal activities (dredging/ brownfield site restoration)?



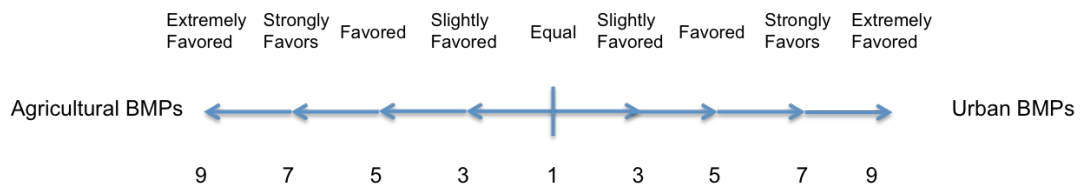
Comments:

13. In regards to Point Source Controls (Structural controls such as mandated process improvements or infrastructure upgrades; or Non-Structural methods such as permitting increases on NPDES and MS4s), which do you believe to have the most impact or to be the most effective?



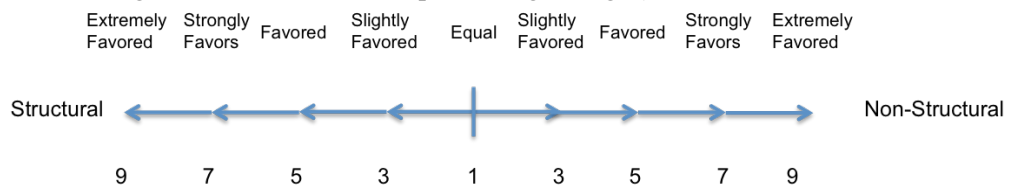
Comments:

14. With Non-Point Source Controls which is the most effective?



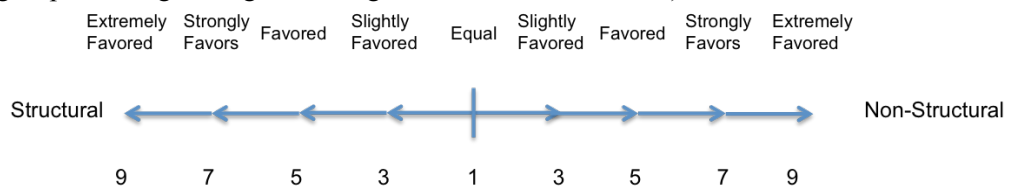
Comments:

15. In relation to Agricultural BMPs which are your preference Structural controls (Land Modification, structural improvements i.e. water control devices, fencing etc.) or Non-Structural (regulation on irrigation, nutrients, etc. or permitting changes)?



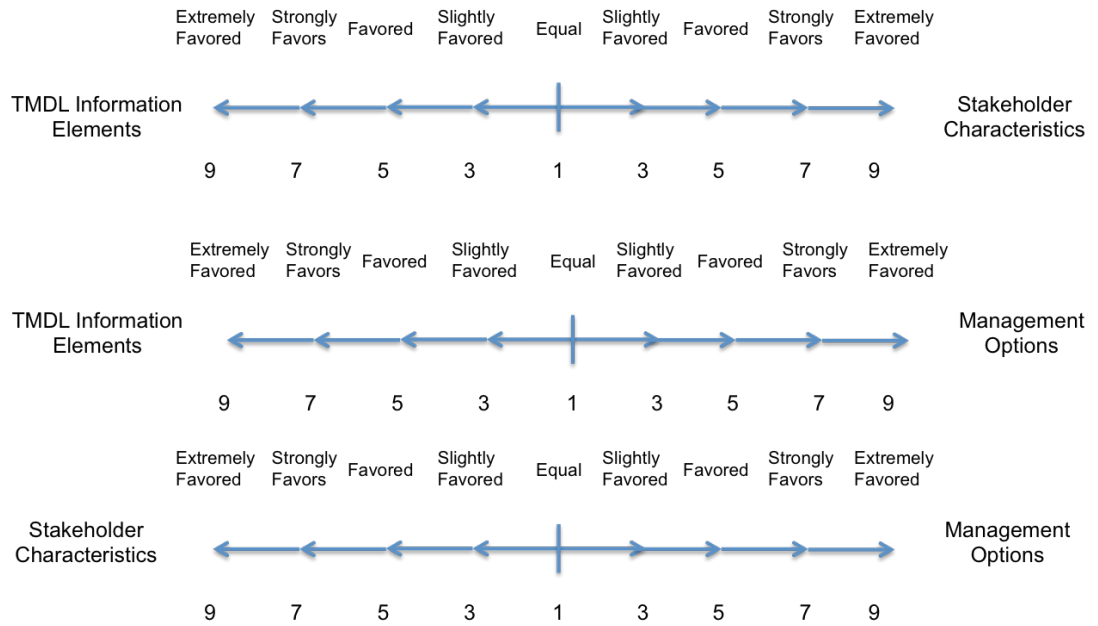
Comments:

16. In relation to Urban BMPs which are your preference Structural controls (upgrades to infrastructure, wastewater upgrades, storm water collection, etc.) or Non-Structural (Ordinance changes, permitting management, regulation of fertilizers, etc.)?



Comments:

17. Taking into consideration all the elements that make up each section (TMDL Informational Elements, Stakeholder Characteristics, and Management Options) how would you rate each section in relation to the others?



Comments:

## Appendix B: IRB Approval Letter



RESEARCH INTEGRITY AND COMPLIANCE  
Institutional Review Boards, FWA No. 00001669  
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4795  
(813) 974-5638 • FAX (813) 974-7091

July 21, 2015

Justin Barthle  
School of Geosciences  
Tampa, FL 33612

RE: **Expedited Approval for Initial Review**  
IRB#: Pro00021441  
Title: Analysis of Managerial Decision-Making within Florida's TMDL Program

**Study Approval Period: 7/21/2015 to 7/21/2016**

Dear Mr. Barthle:

On 7/21/2015, the Institutional Review Board (IRB) reviewed and **APPROVED** the above application and all documents contained within, including those outlined below.

**Approved Item(s):**  
**Protocol Document(s):**  
[USF IRB PROTOCOL.docx](#)

**Consent/Assent Document(s)\*:**  
[Interview Consent Form.docx](#) \*\*Granted a Waiver  
[Online Consent Form.docx](#) \*\*Granted a Waiver

\*Please use only the official IRB stamped informed consent/assent document(s) found under the "Attachments" tab. Please note, these consent/assent document(s) are only valid during the approval period indicated at the top of the form(s). \*\*Waivers are not stamped.

It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve only procedures listed in one or more of the categories outlined below. The IRB may review research through the expedited review procedure authorized by 45CFR46.110 and 21 CFR 56.110. The research proposed in this study is categorized under the following expedited review category:

(6) Collection of data from voice, video, digital, or image recordings made for research purposes.

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Your study qualifies for a waiver of the requirements for the documentation of informed consent as outlined in the federal regulations at 45CFR46.117(c) which states that an IRB may waive the requirement for the investigator to obtain a signed consent form for some or all subjects if it finds either: (1) That the only record linking the subject and the research would be the consent document and the principal risk would be potential harm resulting from a breach of confidentiality. Each subject will be asked whether the subject wants documentation linking the subject with the research, and the subject's wishes will govern; or (2) That the research presents no more than minimal risk of harm to subjects and involves no procedures for which written consent is normally required outside of the research context.

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval via an amendment. Additionally, all unanticipated problems must be reported to the USF IRB within five (5) calendar days.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,



Kristen Salomon, Ph.D., Vice Chairperson  
USF Institutional Review Board