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An Inventory and Assessment of Data Requirements for the Development of a Coes Pond Watershed Management Plan

An Interactive Qualifying Project

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Submitted By

Alex Venditti

Brian Flynn

Edward Giles

Ryan Loucks

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Advisor: Derren Rosbach

Co-Advisor: Paul Mathisen

Abstract

Once a site of great public appeal, Coes Pond in Worcester, Massachusetts has become a forgotten glory. In 2014, the Coes Zone Task Force began planning, and working, to revitalize the pond. Utilizing local and state resources, we built and analyzed an inventory of physical documents from stakeholders, and data layers from MassGIS archives, focusing on what data are available, and what remain to be collected, in order to support the task force. The results from this project can be used to assist the Coes Zone Task Force, and other organizations and individuals, in their goal to revitalize Coes Pond, and its encompassing watershed.

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Executive Summary

The purpose of this project was to develop a framework for a watershed management plan for Coes Pond in Worcester Massachusetts. Coes Pond was once a popular recreational area, however use has decreased over the years, the water was often closed due to high levels of E.coli during some seasons, and the beach property had not been maintained. As early as 1998, a master plan for the pond was developed, but little had been done to actually implement the changes planned. As of 2014 and 2015, organizations such as the Coes Zone Task Force (CZTF) have been working to revitalize the beaches with changes such as improving facilities like the bathhouse, adding new sand to the beaches, and hosting public events in order to raise awareness of the revitalization of the pond. It was our goal to determine stakeholder needs, perform an inventory and assessment of data requirements necessary for the creation of a watershed management plan, collect and organize what data already exists, and what data remains to be collected. By locating, categorizing, and organizing this information, we hope to facilitate efforts to improve the condition of the water at Coes.

An additional requirement is the need to store data in a central, public location that anyone can access. Currently, the data is scattered between different parties, and much of it is not digitized, making it difficult for anyone to easily access the information necessary to construct a watershed management plan for Coes, or to simply learn more about the state of the waterbody. We evaluated different methods to store information and determined that it would be useful for our stakeholders, and others, to have as much data as possible be digitized and stored online. This would increase access to information, making it easier to perform an analysis on the status of the

pond. Due to the needs of the stakeholders and findings of this project, we recommend that the stakeholders utilize a cloud based data storage solution like Dropbox ™.

The first step for this project was to determine stakeholders. This included anyone who was likely to be interested in the revitalization, or state of health of Coes Pond. We were able to find several individuals on the state level who provided us with valuable information, and met with the CZTF, a group who is dedicated to the revitalization of Coes Pond. The results are organized within page four of the accompanying Excel workbook, titled Stakeholder Map.

Our methods of data collection included reaching out to stakeholders via email, inventorying physical documents that were held by members of the Coes Pond Task Force, and interviewing certain individuals who were able to give us insight on different aspects of testing and watershed management processes. Much of the information regarding the status of Coes Pond is not available through online public resources, so we had to ask city workers, and find old records of events from individuals who had physical documents on hand, such as Lance McGee and John Reed from the CZTF.

The physical documents obtained from members of the CZTF were inventoried and organized into a spreadsheet which is located in the accompanying Excel workbook on page one titled Coes Zone Task Force Resources. These documents are primarily organized by date, as we determined that the age of the document was a primary factor in its relevance to our project. Along with the date and title is a description of the document, and details about what requirements for a watershed management plan it contains.

We also obtained testing results from some individuals in the Department of Environmental Protection (DEP), and many old reports dating back as far as 1988 and as recently as 2013. It was our task to categorize these resources in a way that would show what contained useful, relevant information, and what did not. In the end, the most useful documents were those that were dated no older than 2010, as over time testing results become less relevant due to factors such as changing conditions and differences in testing procedures.

The next step in the process was to analyze the resources we had attained in order to figure out what data existed for Coes, and what still needed to be attained. We used the EPA's Handbook for Developing a Watershed Management Plan as a guide for what types of data were required. The necessary data categories, outlined in the EPA's handbook, included: physical and natural features, land use and population characteristics, waterbody and watershed conditions, pollutant sources, and waterbody monitoring data, which were further broken down into more specific sub-categories.

We were able to find some maps, as well as GIS data, that showed the watershed boundaries and topographic maps that give insight on how water in the area flows. This information is important for understanding the hydrology of the area. Data on soils was practically nonexistent for the Coes area, and thus is an area demanding improvement. We were able to gather climatological data though the National Climatic Data Center, and also identify areas of conservation, protection, and restoration. These areas included the old Coes Knife property, Coes Beach and

Bathhouse, and the former Knights of Columbus site. We were also able to confirm that Coes Pond is stocked with trout. This data all falls under the physical and natural features category.

For data regarding land use and population characteristics, we found a table from a 2002 study that detailed the land usage percentages from that time, as well as more recent GIS data that showed a visual representation of the current land uses in the Coes area. Inside the same 2002 study were suggested management techniques along with estimated costs, for Coes Pond. Unfortunately we were not able to locate land management practices currently in place for the area surrounding Coes.

The waterbody and watershed conditions data we located dealt primarily with water quality standards. We determined that Coes Pond is a class 4c waterbody, which means that it is impaired, but the cause is not pollution. This also meant that the pond does not require a TMDL, and does not need to be included on the 303(d) list, or in the 305(b) report. The recorded cause of this impairment is an invasive plant species called Eurasian water milfoil. Invasive species disrupt the ecosystem within the pond, taking nutrients away from the natural inhabitants, or growing excessively because they have no natural predator and impeding the growth of other plants and aquatic life.

Data regarding pollutant sources revealed that non-point sources were known, but point sources were not. This does not mean that point sources do not exist, but suggests that if they do exist, they have not been identified yet. Non-point sources of pollution were identified in a study on the Worcester airport drainage system in 2001, but work has been done on the airport since then,

so it is important that the topic is revisited with past results in mind to determine if the area still poses as a hazard to Coes Pond.

Waterbody monitoring data was found regarding water quality and flow, biological data, and geomorphological data. In a 2012 report, it was determined that fish consumption in Coes is impaired, and Coes is also known to have a very slow rate of flow, which could be a contributing factor in the ongoing state of impairment in the pond. Biological factors include exotic species such as Eurasian Water Milfoil, which could have been accidentally or purposely introduced into the water system. These exotic plants cause a non-pollutant form of impairment, but create a disturbance in the ecosystem, which can result in overall poor health of the waterbody. There is a lack of geomorphological data, which would be useful in determining the impact of the rising silt and sand levels within the pond which have contributed to the disuse of the water as a swimming and boating spot.

Knowing what data exist and where they are located is useful in constructing a watershed management plan, but the main focus of future work should be on identifying and filling data gaps. By locating some of the data gaps in this report, we have made progress towards a watershed management plan for Coes.

1 Introduction

In 1972, the Clean Water Act was passed to establish a basis for regulating and monitoring the discharge of pollutants into the waters of the United States. Since the late 1980's increased public awareness and support led to the prominence of a new method of water quality. From this awareness the watershed management approach was developed. A watershed management plan can be defined as "a strategy that provides assessment and management information for a geographically defined watershed, including the analysis, actions, participants, and the resources relating to the developing and implementation the plan." (United States Environmental Protection Agency Office of Water, 2008).

The purpose of this project was to develop a framework for a watershed management plan for Coes Pond in Worcester Massachusetts. We focused on identifying key stakeholders, and working with those stakeholders to identify key issues and goals for Coes Pond. Although there have been plans for improving the beaches of Coes Pond in the past, there has not been significant change. Most of the improvements planned for the pond are centered on making it fishable and swimmable and improving the quality of the beaches and facilities, such as those shown in Figure 1 – Master Plan (1998) - Coes Beach and Bathhouse Property. For this project, we worked closely with stakeholders in order to share information, and increase collaboration, on a plan for improving the quality of Coes Pond.

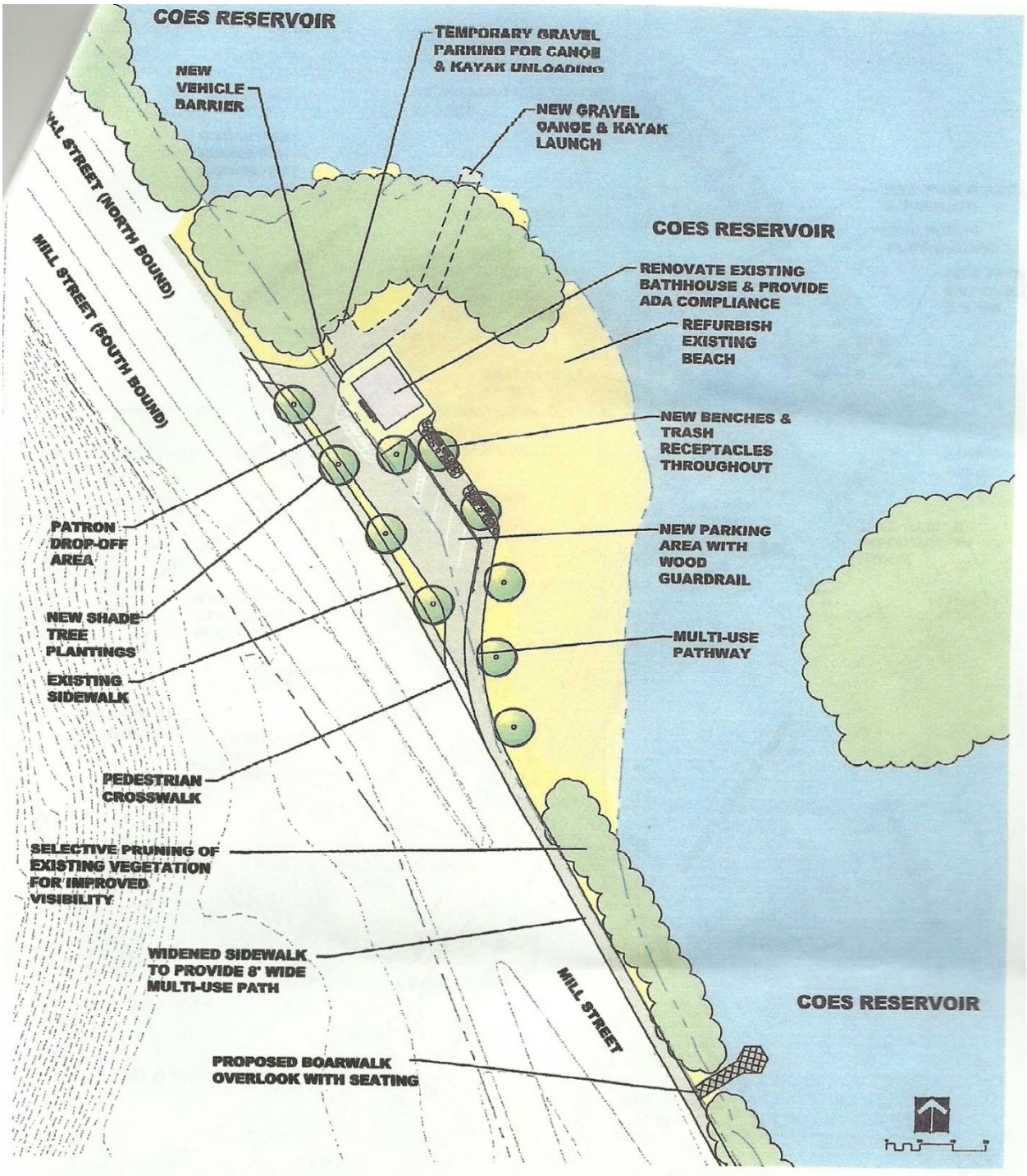


Figure 1 – Master Plan (1998) - Coes Beach and Bathhouse Property

(Halvorsen and Associates, 2011)

The Coes Zone Task Force (CZTF) has been holding regular meetings, and developing plans and strategies to improve these aspects of the Pond area in 2014, and 2015. The mission of the CZTF is "to articulate what stewardship of these natural resources means and to work with civic organizations, government, business, schools and universities to make this vision a reality. The CZTF envisions improved stewardship of the ponds, streams and parklands in the "Coes Zone" (the region around Coes Pond and Patch Pond/Reservoir in Worcester). The CZTF also envisions significant economic and societal benefits that will result from this improved stewardship." (McKee, 2015) In addition to aesthetic improvements, the pond is in need of water quality control as well. One common problem with urban ponds, such as Coes Pond, is that E. coli will often flare up during the summer months, and requires beach closures. There was also speculation about whether the sediment at the bottom of the pond is dangerous, and positive tests for fecal coliform in the water was a result of increased geese populations are present. When more people are using the pond on a regular basis, geese will not be as inclined to take up residence within it, and this problem can eventually subside as a cleaner pond attracts more visitors. In order to speed up this process, efforts are sometimes made to purposely scare the geese off to stop them from further contaminating the water.

In this report, we relied on the EPA's Handbook for Developing Watershed Plans for Restoring and Protecting Our Waters (2008) as a guide to collect the type of data that would be useful in the process of building a watershed plan. Although an entire watershed plan would need to be made for a watershed, such as the Tatnuck Brook Watershed which contains Coes Pond and Coes Reservoir, we were focused on the state of Coes Pond, and the data had already been collected on it. By finding out what information already existed, we could determine data gaps,

and identify what data needs to be collected in order to determine what the underlying water quality issues are in the pond. Our hope was that with this report, we can contribute to regional water management efforts.

Our objectives were to categorize stakeholders, locate data, inventory data, characterize the data that we collected, and provide recommendations for data storage. Based on these objectives we developed practical methods to collect existing data and determine what data is still needed. In the final section, we summarize the data that we found, and suggest future action.

2 Background

2.1 A Brief History of Coes Pond

Coes pond and the connecting reservoir are located between Mill Street and Coes Street in Worcester Massachusetts, and is the former site of the Coes Wrench Company that was located on the edge of the pond. "[Coes Pond's] total acreage of 20.79 acres incorporates five properties around Coes Reservoir (commonly referred to as Coes Pond), including the Coes Beach and Bathhouse, Coes Knife Dam, Columbus Park, the former Fenton Parcel and the former Knights of Columbus" (Antonelli, 2015). A topographical map of Coes Pond, Coes Reservoir, and the overall Coes Reservoir watershed is depicted below in Figure 2. This figure can be used to get an idea of the relative size of Coes, and understand its proximity to the residential areas that are present mostly above, below, and to the right of the waterbody.

In 1972, the Clean Water Act was passed to establish a basis for regulating and monitoring the discharge of pollution into the waters of the United States, but until then, and even after, progress was so slow that as recently as 1990, the The United States Environmental Protection Agency (EPA) had called the Blackstone, "The most polluted river in the country with respect to toxic sediments." (Rhode Island Rivers Council, 2015) Because the Coes Reservoir Dam had been constructed after the Civil War to provide a power source for the Coes Wrench Factory, it had collected sedimentary pollution from these sources for a long period of time. In the mid 1990's, Weston & Sampson Engineers, an environmental and infrastructure consultant company, was selected to evaluate the condition of the design improvements that were to be done to the dam. The dam needs to be rehabilitated "while addressing the need to remove contaminated soils from the site." (Weston & Sampson, Inc., 2006)

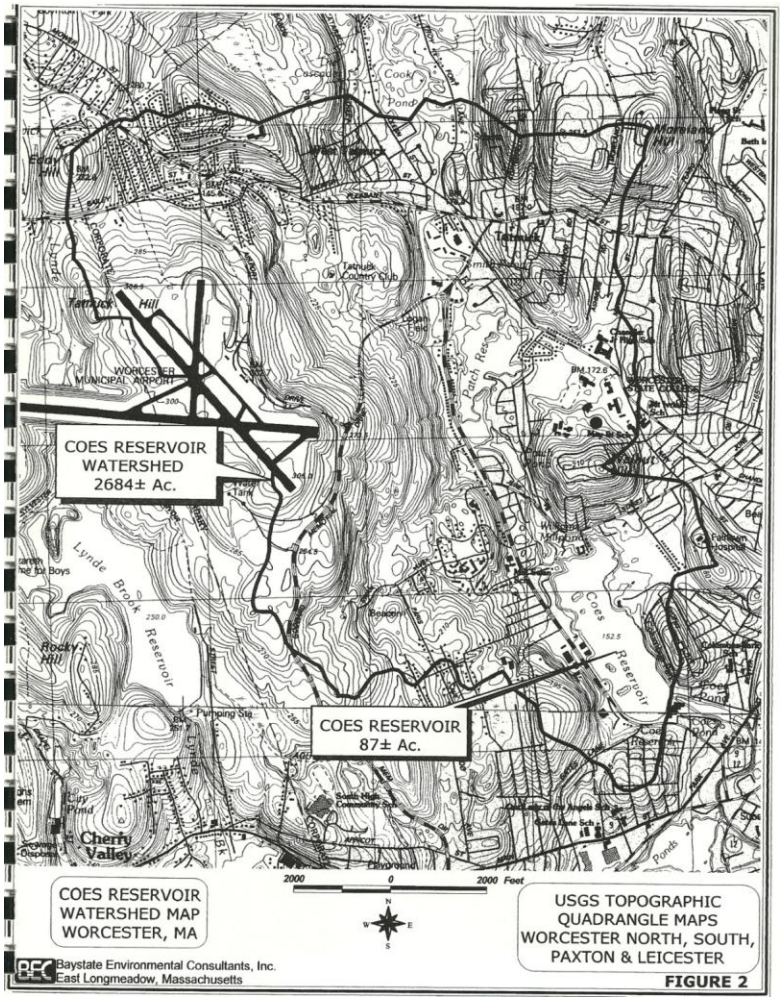


Figure 2 – Coes Reservoir Watershed Map, Worcester, MA

(Baystate Environmental Consultants, Inc., 2002)

Coes Pond used to be a popular place for residents of the area to relax. "It was also a popular fishing spot and the home of many fishing derbies" (Kotsopoulos, 2014). Over the years, however, silt and sediment build-up have reduced the depth of the water making activities like boating impossible in some areas. The silt and sediment build-up has also made swimming and fishing less desirable activities, and as the condition of the beach deteriorated, people stopped spending their time there.

The new CZTF is currently undergoing planning to fund, and work on, rehabilitation of the Coes Beach and Bathhouse area. In addition, a group called the Friends of Coes Pond is looking to "… enlist the support and help of city officials, businesses, agencies, schools and universities to restore, renew, develop and beautify one of Worcester's finest water and open space resources…," and "… develop an adjacent open space — the former Coes Knife factory property — into an inclusive universally-designed park/playground" (Kotsopoulos, 2014). Figure 3, below, depicts the upper and lower Coes Pond with labeled places of planned improvements from the 1998 Master Plan for Coes Pond. The CZTF force has been taking many of these improvements into their own hand as of 2014 and 2015 in order to bring people back to the area with the hope of turning Coes back into a popular place for residents of Worcester to enjoy themselves.

As awareness for the issues of beach and water pollution becomes more widespread, groups dedicated to the revitalization of water bodies are able to gain momentum and improve the quality of their water and public amenities and return them to the state they once held. It is important that these efforts be supported not only for the health of the area, but so that the pollution problem is not perpetuated into the future. By working together with different interested parties, and including the local community in remediation efforts, these waterbodies can be returned to a state where families can enjoy spending time in a safe, clean environment by swimming, fishing, or just using the public amenities provided by the cities or organizations that own the space.

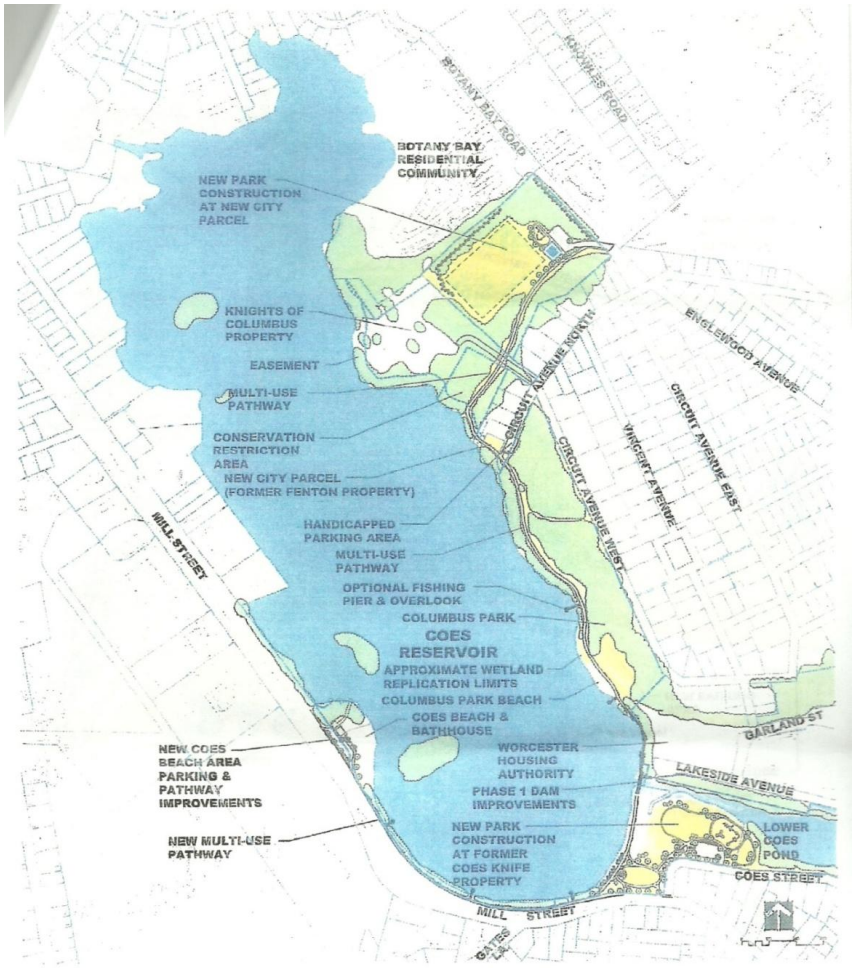


Figure 3 – Master Plan (1998) - Public Open Space Properties Surrounding Coes Pond

(Halvorsen and Associates, 2011)

2.2 Urban Watersheds

The EPA defines urban watersheds as topographical regions densely populated with people, business, and buildings with concentrated environmental impacts (Environmental Protection Agency, 2014). Worcester Massachusetts, the second largest city by population in New England, fits this description. Worcester has a population of over 180,000 and a population density over 4,000/ per square mile, with a rich history of manufacturing.

Urban watersheds are unique in topography, as well as unique in the concentration of people, manufacturing, waste water management and sources of pollution. The city of Worcester, being part of an urban watershed has created many difficulties and issues for bodies of water in the area. Some of these difficulties include contamination from brownfields, runoff from airports, invasive plants, as well as other issues such as vandalism and lack of maintenance. Research shows that "A large percentage of affected land lies within urban area" (Kaufman, Rogers, & Murray, 2011). This holds true for many bodies of water located both in and the surrounding Worcester area, such as Lake Singletary in Holden Massachusetts where a management plan was recently created and implemented. Due to the wide variety of possible pollution sources, urban watersheds must be dealt with separately to better accommodate its own specific characteristics, or rather urban watershed planning must encompasses more than the traditional fields of watershed management (McCray, 2007).

Specific examples of pollutants that occur in larger proportions in urban watersheds are wet and dry atmospheric deposition, street refuse, vegetation and other organic materials, traffic emissions, urban erosions and road de-icing. Along with specific pollutants other issues affect urban watersheds. Since urban watersheds require unique methods of regulating and maintenance it is important to implement and use a plan to that is capable supporting such a system. (Novotny, Sung, Bannerman, & Baum, 1985) One such method of regulating and maintaining an urban watershed is the use of a watershed management plan.

2.3 Watershed Management

Watershed management is a term used to describe the implementation and maintenance of land use and water management practices to regulate and improve water quality and other resources in

a watershed. Since a watershed is a geographically defined area, the body of water involved is greatly affected by many factors in the area. These loads are difficult to quantify since it is difficult to identify the origins of the contamination from within the watershed. Watershed management provides a way to identify and regulate these issues (Connecticut Department of Energy & Environmental Protection, 2015). Watershed management manifests itself in many forms; one common prevalent way is the development and implementation of a watershed management plan.

A watershed management plan is essentially a goal driven process designed around a topographically defined watershed. Specifically a watershed management plan is tool that can be used to achieve water resource goals that provides assessment and management information for a geographically defined watershed (Indiana Department of Environmental Management, 2014).

A watershed management plan is not a single process or solution. It is a combination of various methods, information, and regulations executed together. A watershed management plan often includes or absorbs other programs already in place for a specific watershed. This includes but isn't limited to total maximum daily loads (TMDL's), master and various management plans (United States Environmental Protection Agency Office of Water, 2008).

Another major component of watershed management plans should be the heavy involvement and interests of the stakeholders. Since the process is developed around the goals and needs of the stakeholders, it relies on them to help determine and understand the issues, and ultimately

produce a solution. The large amount of stakeholder involvement creates a "holistic" aspect. This means stakeholders involved tend to have interests beyond the condition of the water quality. Coes Pond's unique scenario, location in an urban watershed, and history, has created many issues for many different levels of governments and various organizations.

For example the impairments to the pond have put additional financial burden on the City of Worcester to maintain and mend the area. Many stakeholders also live and operate in close vicinity of the pond. Organizations such as The Knights of Columbus operate a chapter next to Coes Pond, as well as many others living on and next the pond. These stakeholders have many concerns with the area, most revolving around the health and safety associated with the pond.

The development and implementation of a watershed management plan follows a process similar to cooperative federalism, in which varying levels of government are able to delegate smaller roles and responsibilities to various smaller groups. The watershed management plan protocol calls for "agencies to work with state and local governments, citizens, and other interest groups to coordinate efforts to protect and manage natural resources" (Moore & Koontz, 2003). These smaller organizations can focus their abilities to complete their goals in a more intimate and thorough level. These levels start with federal and state legislation, then to state level enforcement of policies, and finally down to the municipal and community level where the plan is actually implemented and sustained.

2.3.1 Developing a Watershed Management Plan

The "*EPA Handbook for Developing a Watershed Management Plan"*, proposes a comprehensive process for developing a watershed management plan in a series of steps. Each step is an essential building block in creating the pyramid of success. The steps can be seen in Figure 4 below.

Figure 4 – Steps for Developing a Watershed Management Plan

Step 1: Build Partnerships
The Term "Build Partnerships" refers to identifying vital stakeholders involved in the watershed. As stated above a watershed management practice is an extensive process that relies heavily on the involvement of the stakeholders. From the stakeholders, the key issues of concern and preliminary goals for the watershed have to be determined and outlined. These issues and concerns are generally determined from individual goals of the stakeholders as well as from public outreach about the watershed.
Step 2: Characterize the Watershed
The second step in developing a watershed management plan is to gather all the necessary data to create the plan. A major part of this step is to gather existing data and create an inventory. After relevant existing data is organized into an inventory, data gaps have to be determined, so any remaining necessary data can be collected. After sufficient data is collected, it must be analyzed in order to estimate and identify causes, and sources, of pollution that need to be controlled.
Step 3: Finalize Goals and Identify Solutions
The third step in the process is to set overall goals and objectives for the plan. Also in this step indicators and targets are set up, load reductions are determined if needed, and critical areas are identified. After the previous items mentioned are completed, the final action for Step 3 is to develop management measures to achieve the determined goals.

Figure 4 – Steps for Developing a Watershed Management Plan Continued

Step 4: Design an Implementation Program
The fourth step in the process is to develop programs to implement and evaluate the watershed management plan. First an implementation schedule is developed. Then milestones are created to track the implementation of the plan. The next component of Step 4 is to develop a monitoring component, education component, and an evaluation process. Also technical and financial assistance that will be needed will be determined. The final component in Step 4 is to assign responsibility for reviewing and revising the watershed management plan, which becomes prevalent in Step 5 and Step 6.
Step 5: Implement Watershed Plan
The fifth step is the implementation of the management strategies and practices created in the previous steps. After the plan is implemented, monitoring is conducted, along with educational and informational activities about the watershed.
Step 6: Measure Progress and Make Adjustments
The sixth step serves as a continuous step to allow for changes and improvements in the watershed management plan. In Step 6, information from monitoring and evaluating the watershed is analyzed. The results are shared with the stakeholders, and annual work plans and program adjustments are made.

2.4 Stakeholders

Stakeholders for this project were classified as, a person or organization that has an interest in Coes Pond. The goal of many of these stakeholders is to help the community around Coes rebuild and recover from the hardship it has sustained. Stakeholders hold vital information about existing data on the conditions of the pond overtime. Some stakeholders will be members of the community and non-governmental organizations; others will work for state or federal offices. The stakeholders can generally be broken up into three main categories, local, state, and federal. These categories are stated in the EPA handbook for developing a watershed management plan in chapter 3 (United States Environmental Protection Agency Office of Water, 2008).

2.4.1 Local, State, Federal Level Stakeholders

Following the EPA handbook the local level stakeholders are classified as "landowners, county or regional representatives, and local municipal representatives" (United States Environmental Protection Agency Office of Water, 2008). State level stakeholders will include the Department of Environmental Protection as well as the state fish and wildlife, both have interest in the protection of the local environment and will make sure that the habitat is not damaged (United States Environmental Protection Agency Office of Water, 2008). There are multiple federal agencies that would be involved in a watershed management plan, they include Federal Transportation Programs as well as Agricultural Conservation Programs and many more. These programs focus on many different factors but the main link is that they work towards a better environment (United States Environmental Protection Agency Office of Water, 2008).

2.5 Locating Watershed Data

The amount of data needed for a watershed management plan is extensive. One of the biggest challenges of producing a watershed management plan is physically locating appropriate data upon which to base the plan. Some techniques used when trying to locate data includes:

- Create a dialogue with stakeholders
- Scheduling Interviews
- Doing surveys of local people/organizations
- Contacting state agencies (DEP, public health, etc.)
- Online Research

According to the EPA, "local knowledge and anecdotal information from stakeholders are often very important" (United States Environmental Protection Agency Office of Water, 2008). One way to gain access to local knowledge and anecdotal information is to create a dialogue.

Meetings, emails, and actually making an effort to talk face to face with stakeholders are all forms of communication that help create a productive dialogue. More often than not, stakeholders are happy to help in any way they can because they are "people and organizations that have a stake in the outcome" (United States Environmental Protection Agency Office of Water, 2008).

Interviewing stakeholders to determine their goals and interests is a valuable part of any project because it can help guide the work of the team to find specific data. Stakeholders may also know the exact location of data which reduces the amount of work that needs to be done. Conducting interviews will also help generate an intimate understanding of a stakeholder's relationship to Coes Pond and help further evaluate the context of the acquired data.

Conducting interviews is more challenging than it may seem. According to Bruce Berg, "interviews are conversations with a purpose" (Berg, 2007). There are many things you have to consider when conducting an interview, from the type of interview, to the words or phrases you use when asking questions.

There are three common types of interviews: standardized (formal), unstandardized (informal), and semi-standardized (Berg, 2007). The Semi-standardized interviews are the most beneficial in our case, as treating the interview like a sort of open forum can potentially reveal information we did not initially know we had to look for. They have the directed schedule of a formal interview, with the flexibility of an informal interview. This means that there are predetermined questions created for each interview but the interviewer has the option to digress from the schedule to ask

other questions. The semi-standardized interview type will help the interviewer to develop a better rapport with the interviewee. Using the semi-standardized interview platform offers the best of both worlds and allows the interviewer to obtain the best information.

The EPA recommends contacting state environmental agencies because they "routinely collect biological, hydrological, and water quality information for the waters in the state" (United States Environmental Protection Agency Office of Water, 2008). State environmental agencies include several divisions and offices, many of which might be useful in characterizing the watershed and some of which might be irrelevant. It's useful to go to a state environmental agency's Web site to learn what types of offices work in your state and identify potential sources of relevant information. In addition to state environmental agencies, several other state agencies might be useful in characterizing your watershed and potential sources. For example, the Division of Natural Resources or Department of Fish and Game can provide information on wildlife habitats and populations, and the Department of Agriculture can provide agricultural statistics for different counties. Although most information can be found through the other techniques, it is useful to begin with online research to see what is easily accessible.

2.6 Inventorying Data

Once data sets and existing studies have been collected, the next step is to document the relevant available data by creating a data inventory. A data inventory provides a comprehensive, ongoing list of available monitoring and watershed data based on criteria provided by the EPA's Handbook for Developing a Watershed Management Plan (United States Environmental Protection Agency Office of Water, 2008). The information in this section below is paraphrased

from The EPA's Handbook for Developing a Watershed Plan to provide a background on the subject of inventorying data.

The EPA handbook on developing a watershed plan recommends organizing a data inventory by data type. The most likely types of data to be collected are tabular data, reports, anecdotal information, and GIS data. The EPA suggests organizing data in this manner so that it is easy to locate and differentiate between different types of data that someone might be interested in. If this method of organization is adopted, different types of data can be grouped together and summarized more easily, making for a much more useful inventory that can continue to evolve as the project moves forward.

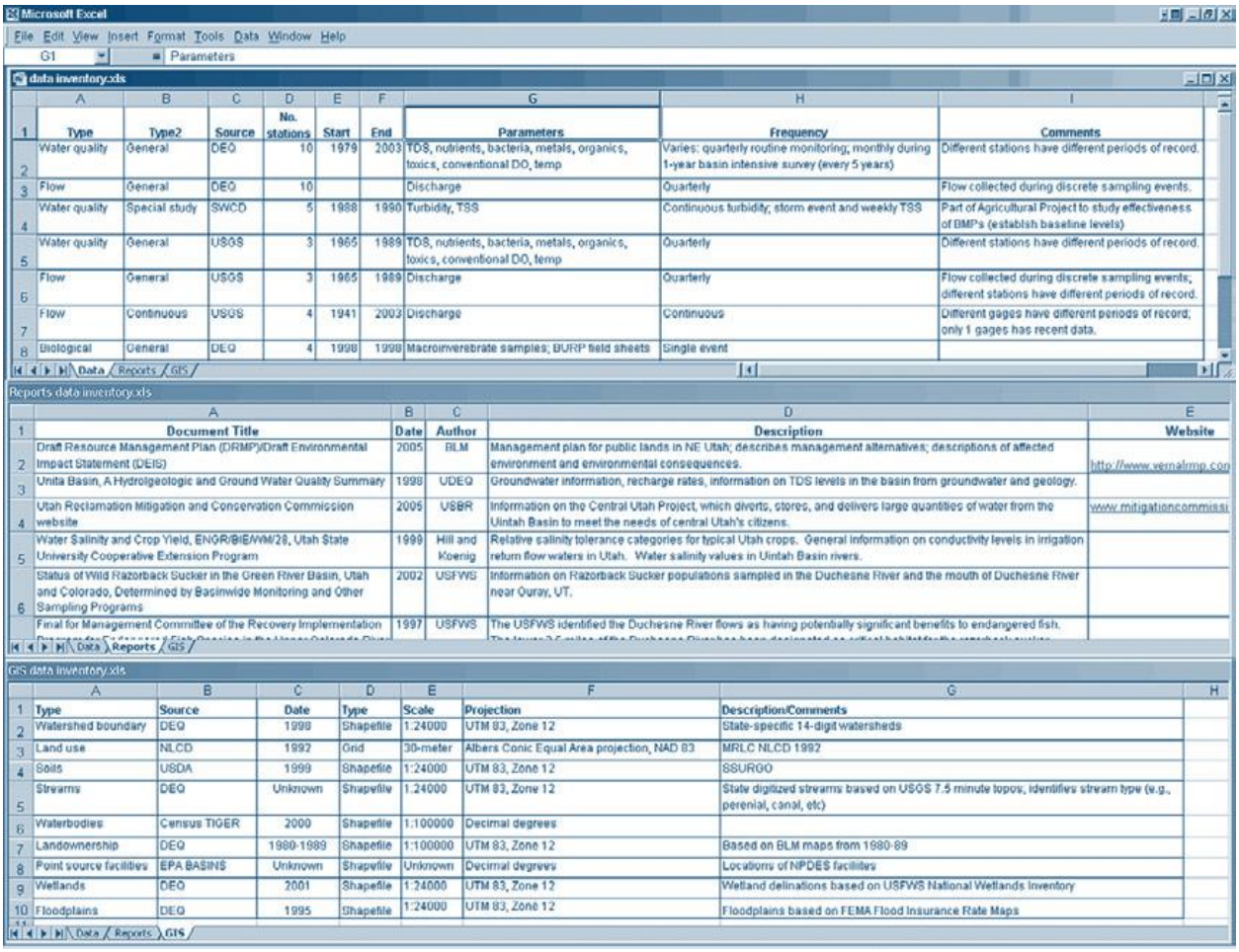
The EPA also suggests containing collected data within a database or spreadsheet. Databases are superior in that information can be queried with keywords, or content type, which translates to simpler use and an increase in overall effectiveness for those stakeholders who are only interested in certain information. In addition, databases are more effective for larger amounts of information. Spreadsheets are adequate, however, as the data can be organized in the same way as it would be in a database, and different types of data regarding a topic can still be separated into useful subcategories. The decision between database and spreadsheet is mostly a case of utility or preference, or overall size of the project. It is important to consider, at this step, how the inventoried information should be itemized, as this will be difficult to change later on into the project, depending on the pace. It is also important to consider the goals of your stakeholders, and what their own personal interests are. Involved stakeholders may prefer one method, or have

resources that would make one simpler than the other, such as pre-existing databases or spreadsheets.

It is also suggested that information that has not, or cannot, be obtained should be documented within the database or spreadsheet, because the importance of different data is dependent on the goals of the data collectors or stakeholders. In the event that there are plans to gather information in the future, by clearly identifying what data has not been obtained, it becomes easier to create goals for obtaining this information. Performing this type of data differentiation can make future decisions much easier and effective. Less time will be needed to figure out what data needs to be compiled, and the waste of time obtaining data that has already been collected will be avoided.

It is also possible that once analysis of data begins; there might be more information that should be added to the data inventory. The EPA suggests that the inventory is constructed in a way that makes it expandable so that it will be easy to add any additional information.

When the data is properly organized, anyone can easily go in and find what they are looking for, or to discover that some data has been contained in places they were unaware of. An example of a data inventory from the EPA handbook can be viewed within Figure 5 – Example Fields in a Data Inventory. For all of the data collected, it is helpful, both to stakeholders and future parties, to document the physical location of the files. An inventory is not very useful if nobody knows where to find the documents that it outlines.



data inventory.xls

	Type	Type2	Source	No. stations	Start	End	Parameters	Frequency	Comments
2	Water quality	General	DEQ	10	1979	2003	TDS, nutrients, bacteria, metals, organics, toxics, conventional DO, temp	Varies: quarterly routine monitoring; monthly during 1-year basin intensive survey (every 5 years)	Different stations have different periods of record.
3	Flow	General	DEQ	10			Discharge	Quarterly	Flow collected during discrete sampling events.
4	Water quality	Special study	SWCD	5	1988	1990	Turbidity, TSS	Continuous turbidity; storm event and weekly TSS	Part of Agricultural Project to study effectiveness of BMPs (establish baseline levels)
5	Water quality	General	USGS	3	1965	1989	TDS, nutrients, bacteria, metals, organics, toxics, conventional DO, temp	Quarterly	Different stations have different periods of record.
6	Flow	General	USGS	3	1965	1989	Discharge	Quarterly	Flow collected during discrete sampling events; different stations have different periods of record.
7	Flow	Continuous	USGS	4	1941	2003	Discharge	Continuous	Different gages have different periods of record; only 1 gages has recent data.
8	Biological	General	DEQ	4	1998	1998	Macroinverebrate samples; BURP field sheets	Single event	

Reports data inventory.xls

	Document Title	Date	Author	Description	Website
2	Draft Resource Management Plan (DRMP)/Draft Environmental Impact Statement (DEIS)	2005	BLM	Management plan for public lands in NE Utah; describes management alternatives; descriptions of affected environment and environmental consequences.	http://www.vernalrmp.com
3	Unita Basin, A Hydrolgeologic and Ground Water Quality Summary	1998	UDEQ	Groundwater information, recharge rates, information on TDS levels in the basin from groundwater and geology.	
4	Utah Reclamation Mitigation and Conservation Commission website	2005	USBR	Information on the Central Utah Project, which diverts, stores, and delivers large quantities of water from the Uintah Basin to meet the needs of central Utah's citizens.	www.mitigationcommissi
5	Water Salinity and Crop Yield, ENGR/BIE/WM/28, Utah State University Cooperative Extension Program	1999	Hill and Koenig	Relative salinity tolerance categories for typical Utah crops. General information on conductivity levels in irrigation return flow waters in Utah. Water salinity values in Uintah Basin rivers.	
6	Status of Wild Razorback Sucker in the Green River Basin, Utah and Colorado, Determined by Basinwide Monitoring and Other Sampling Programs	2002	USFWS	Information on Razorback Sucker populations sampled in the Duchesne River and the mouth of Duchesne River near Ouray, UT.	
	Final for Management Committee of the Recovery Implementation	1997	USFWS	The USFWS identified the Duchesne River flows as having potentially significant benefits to endangered fish.	

GIS data inventory.xls

	Type	Source	Date	Type	Scale	Projection	Description/Comments
2	Watershed boundary	DEQ	1999	Shapefile	1:24000	UTM 83, Zone 12	State-specific 14-digit watersheds
3	Land use	NLCD	1992	Grid	30-meter	Albers Conic Equal Area projection, NAD 83	MRLC NLCD 1992
4	Soils	USDA	1999	Shapefile	1:24000	UTM 83, Zone 12	SSURGO
5	Streams	DEQ	Unknown	Shapefile	1:24000	UTM 83, Zone 12	State digitized streams based on USGS 7.5 minute topos; identifies stream type (e.g., perenial, canal, etc)
6	Waterbodies	Census TIGER	2000	Shapefile	1:100000	Decimal degrees	
7	Landownership	DEQ	1980-1989	Shapefile	1:100000	UTM 83, Zone 12	Based on BLM maps from 1980-89
8	Point source facilities	EPA BASINS	Unknown	Shapefile	Unknown	Decimal degrees	Locations of NPDES facilities
9	Wetlands	DEQ	2001	Shapefile	1:24000	UTM 83, Zone 12	Wetland delinations based on USFWS National Wetlands Inventory
10	Floodplains	DEQ	1995	Shapefile	1:24000	UTM 83, Zone 12	Floodplains based on FEMA Flood Insurance Rate Maps

Figure 5 – Example Fields in a Data Inventory

(United States Environmental Protection Agency Office of Water, 2008)

An inventory can also be useful in identifying data gaps, and more specific data needs will be identified as information is characterized. This may make the analysis easier, as an idea of what types of data there are, and are not, should already exist.

At any point during the inventorying step, if the stakeholders have access to the data, they may also be able to provide insight on what types of data you are likely to collect and help you create

more useful subcategories that are relevant to their direct interests. This is important both for the depth of the project, as well as the degree to which the information provided is useful in terms of what stakeholders hope to attain through a watershed management plan. This inventory is not just a list; it is an integral communication tool.

2.7 Geographic Information Systems

A geographic information system, commonly referred to as a GIS, is a tool used to store and display geographic and spatial information. Often times GIS is shown as a set of data layers on a map. These layers can relate to political settings and boundaries, environmental factors, and even cultural factors that exist in an area. GIS data layers are very useful for watershed management because it allows a visual representation of a geographically defined area, which may be a watershed.

GIS becomes especially useful for drawing correlations between two or more factors in a geographically defined area. If the factors considered are data layers, they can be placed on top of each other, possibly looking for an overlap, or for trends. Specifically GIS can be useful by combining information from different sources to derive meaningful relationships (Massachusetts Office of Geographic Information (MassGIS), 2015). Furthermore while many different data layers exist for a certain area GIS applications allow for only specific selected combinations to be displayed, giving a more accurate and controlled representation of an area (United States Environmental Protection Agency Office of Water, 2008)

Another more specific example of how GIS relates to watershed management relates to preliminary water quality analysis of a watershed. The EPA recommends in section 5.9.1 of the

EPA Handbook for *Developing a Watershed Management Plan* to use existing water quality data in conjunction with the GIS applications in order to find trends in the area. This allows for GIS a relevant and important role in the preliminary steps of developing a watershed management plan. (United States Environmental Protection Agency Office of Water, 2008)

Important considerations must be taken when using GIS as an evaluation for a watershed. Often times GIS files can contain geographically relevant information, but the scope of the data and information may not be relevant. This is due in part that many GIS files are comprised of data for specific time periods. This allows for an additional dimension to be added to the analysis, but also adds a risk of discrepancies between the GIS information and the actual conditions. When used effectively GIS has the potential to be a powerful and useful tool to analyze and to establish preliminary steps to developing a watershed management.

2.8 Analyzing Data

Possibly the most important aspect of the analysis of data in any watershed management plan is to "Incorporate Stakeholders' concerns and goals" (United States Environmental Protection Agency Office of Water, 2008). Our project incorporated the stakeholders' chief goal of revitalizing Coes Reservoir by providing a framework that could be used to develop a watershed management plan. The goals and concerns of the stakeholders are important because these are the people who know and use the pond. They can help guide a WMP to accomplish specific goals or address specific concerns. For example, if a stakeholder's goal is to make a certain watershed fishable and swimmable, the watershed management plan will be customized to attain that standard. Generally speaking, the types of data that are necessary for a WMP are explained

in the following tables; Table 1, Table 2, and Table 3, excerpted from chapter 5 in the EPA's handbook for Creating a Watershed Management Plan.

These tables list the main classes of data needed for a WMP, and the subcategories that embody each of the main classes of data. The following paragraphs, paraphrased from the EPA handbook, explain each of the main the classes of data and their respective subcategories.

Table 1 – Physical and Natural Feature Data Typically Used for Watershed Characterization

Data Type	Typical Uses of Data
Physical and Natural Features	
Watershed boundaries	• Provide geographic boundaries for evaluation and source control • Delineate drainage areas at desired scale
Hydrology	• Identify the locations of waterbodies • Identify the spatial relationship of waterbodies, including what segments are connected and how water flows through the watershed (e.g., delineate drainage areas contributing to wetlands)
Topography	• Derive slopes of stream segments and watershed areas (e.g., to identify unstable areas, to characterize segments and subwatersheds in watershed modeling) • Evaluate altitude changes (necessary when extrapolating precipitation from one area to another)
Soils	• Identify potential areas with higher erosion rates, poor drainage, or steep slopes • Use to delineate subwatersheds and develop input data for models
Climate	• Provide information about loading conditions when evaluated with instream data (e.g., elevated concentrations during storm events and high flow) • Drive simulation of rainfall-runoff processes in watershed models
Habitat	• Describe area's ability to support aquatic life, and identify areas at risk of impairment • Support defining stressors that could be contributing to impairment • Identify shading or lack of riparian cover • Support identification of potential conservation, protection, or restoration areas • Identify any in-stream flow alterations or stream fragmentation
Wildlife	• Identify special wildlife species to be protected • Identify potential sources of bacteria and nutrients

Table 2 – Land Use and Population Characteristics, and Waterbody and Watershed Conditions Data Typically Used for Watershed Characterization

Land Use and Population Characteristics	
Land use and land cover	• Identify potential pollutant sources (e.g., land uses, pervious vs. impervious surfaces) • Provide basis for evaluation of sources, loading, and controls • Provide unit for simulation in watershed models
Existing land management practices	• Identify current control practices and potential targets for future management • Identify potential watershed pollutant sources
Waterbody and Watershed Conditions	
Water quality standards	• Identify protected uses of the waterbody and associated water quality standards
305(b) report	• Identify the status of designated use support in watershed waterbodies • Identify potential causes and sources of impairment
303(d) list	• Identify known pollutant impairments in the watershed • Identify geographic extent of impaired waterbody segments • Identify potential causes and sources of impairment
Existing TMDL reports	• Provide information on watershed characteristics, waterbody conditions, sources, and pollutant loads (for specific waterbodies and pollutants)
Source Water Assessments	• Identify water supply areas to be protected • Identify potential sources of contamination to the water supply

Table 3 – Pollutant Sources and Waterbody Monitoring Data Typically Used for Watershed Characterization

Data Type	Typical Uses of Data
Pollutant Sources	
Point sources	• Characterize potential point sources for quantifying loads
Nonpoint sources	• Characterize potential nonpoint sources for quantifying loads
Waterbody Monitoring Data	
Water quality and flow	• Characterize water quality and flow conditions throughout the watershed • Provide information on critical conditions, temporal trends, spatial variations, impairment magnitude, etc.
Biology	• Provide information on general health of the watershed, considering long-term effects
Geomorphology	• Describe river/stream pattern, profile, and dimension • Characterize drainage basin, channel/bank morphology • Classify river/stream type, based on morphology • Assess changes to morphology over time

2.8.1 Physical and Natural Features

The physical and natural features section of the EPA handbook provides guidance about the physical and natural features of a watershed that needs to be assessed, including what data is available, why it is important, and where it can be found. The EPA states that information on the physical and natural characteristics of a watershed will define the watershed boundary and provide a basic understanding of the watershed features that can influence watershed sources and pollutant loading. The following subcategories explain the different types of data that comprise the physical and natural features class.

2.8.1.1 Watershed Boundaries

The EPA explains that defining geographic boundaries of a watershed planning effort is the first step in gathering and evaluating data. Although people involved in a WMP generally know the body of water they will be focusing on, providing documentation of its physical boundary and the waterbodies contained in it allows a group to focus on specifics. Depending on the size of the watershed, its boundary might already have been delineated by a state or federal agency.

2.8.1.2 Hydrology

Hydrological data focuses on the movement of water over the land. The movement of water is called the hydrologic cycle and includes precipitation, infiltration evaporation, transpiration, surface runoff and groundwater flow. The EPA states that information on the hydrology of a watershed is necessary to visualize and document the waterbody network, including the locations of all the waterbodies and how they are connected to one another. Knowing the network of water

bodies helps provide a visual map of all the ways pollutant loads can transfer from one point to another (United States Environmental Protection Agency Office of Water, 2008).

2.8.1.3 Topography

Identifying the topography and natural features of a watershed such as hills, mountains or steep slopes can help to determine possible sources of pollution. For example, steep slopes might contribute more sediment loads to a waterbody than flat landscapes because as water runs down a slope and picks up speed, it carries sediment with it. Topographical information is also needed in many watershed models to map movement of runoff and loading across the land and to the waterbody. "Digital elevation models (DEMs) are grid-based GIS coverages that represent elevation. They can be displayed in a GIS and are used for delineating watersheds and displaying topography" (United States Environmental Protection Agency Office of Water, 2008).

2.8.1.4 Soils

The EPA handbook states soils can be an important factor in determining the amount of erosion and stormwater runoff that occurs in a watershed. Soils have inherent characteristics such as: water retention, stability, and water diffusion. Understanding the types of soils in a watershed and their characteristics helps to identify areas that are prone to erosion or are more likely to experience runoff.

2.8.1.5 Climate

Climatological data is used to discover patterns in weather that can contribute to causes of impairment in a watershed. The EPA explains phenomena such as: precipitation, wind, speed,

temperature and snow/ice cover are examples of climatological data which are factors of non-point source pollution

The National Climatic Data Center (NCDC) “is responsible for preserving, monitoring, assessing, and providing public access to the nations treasure of climate and historical weather data and information” (National Climatic Data Center). The NCDC provides reliable climatological data from past to present that can be used to track weather patterns that cause impairment.

2.8.1.6 Habitat

“When characterizing a watershed, it’s important to gather data not only to identify potential pollutant sources but also to identify areas for conservation, protection, and restoration.” The EPA explains that habitat surrounding a waterbody can help prevent water quality impairments and provide the areas wildlife with a healthy environment. If the habitat is kept healthy, the waterbody will be as well (United States Environmental Protection Agency Office of Water, 2008).

2.8.1.7 Wildlife

This section discusses types of wildlife and habitat requirements. The EPA states that wildlife and habitat requirements can aid in identifying areas for protection and conservation in a watershed plan. Understanding the types of wildlife in a watershed can also help identify pollutant sources affecting water quality. Wildlife are an important component of the watershed

ecology and it is important to understand their impact on waterbody conditions when developing a watershed plan.

2.8.2 Land Use and Population Characteristics

This main group of data "discusses data and information for determining the distribution of land use and population in a watershed" (United States Environmental Protection Agency Office of Water, 2008) The EPA explains that different land uses impact physical conditions of the watershed, and display the types of sources active in the watershed. Data on the area's population provides an idea of the potential growth of the area and possible changes in land uses and sources. The following subcategories explain the types of data that comprise the land use and population characteristic class.

2.8.2.1 Land Use and Land Cover

Determining the different land uses in the surrounding area of a watershed is an important factor when trying to understand the present condition of a waterbody. "Land use types influence the hydrologic and physical nature of the watershed. In addition, land use distribution is often related to the activities in the watershed and, therefore, pollutant stressors and sources" (United States Environmental Protection Agency Office of Water, 2008). The previous statement explains that certain land uses can lead to specific types of pollutant problems. For example, if a common land use in an area is related to agriculture, one might expect excessive nutrient loadings in a nearby waterbody to be a prominent cause of pollutant loadings. If the land uses in the area are evaluated, probable sources of pollution can be theorized and attended to.

2.8.2.2 Land Management Practices

The EPA explains that information on how the land is managed in a watershed is helpful to identify both current control practices and potential targets for future management. This information not only supports the characterization of the watershed but is also important in identifying current watershed sources, future management efforts, and areas for additional management efforts.

2.8.3 Waterbody and Watershed Conditions

Information about watershed conditions provides a general overview of the health of the waterbodies in a watershed. This section also describes the types of waterbody uses that should be supported in order to maintain the health of the Watershed (United States Environmental Protection Agency Office of Water, 2008).

2.8.3.1 Water Quality Standards

Current water quality standards for waterbodies within a watershed are needed in order to provide a designated use of a given waterbody. The EPA explains this is so that limits can be set on impairment levels in order to maintain the designated use of a waterbody and so that impairment levels can be evaluated. It is also important to document the designated uses for the waterbodies in a watershed and any relevant criteria for evaluating waterbody conditions.

2.8.3.2 305(b) Report

Under section 305(b) of the Clean Water Act, states are required to prepare a report describing the status of their water quality every 2 years. EPA compiles the data from the state reports,

summarizes them, and transmits the summaries to Congress along with an analysis of the nationwide status of water quality. The 305(b) reports evaluate whether U.S. waters meet water quality standards, what progress has been made in maintaining and restoring water quality, and the extent of remaining problems.

2.8.3.3 303(d) List

303(d) List of Impaired Waters Under section 303(d) of the 1972 Clean Water Act explains that states, territories, and authorized tribes are required to develop lists of impaired waters. Impaired waters are those which do not meet water quality standards, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters. Reviewing your state's 303(d) lists will help you identify any impaired waterbodies in your watershed.

2.8.3.4 Existing TMDL report

As part of EPA's guidance to states for preparing integrated reports, EPA recommends that states use the following five reporting categories to report on the water quality status of all waters in their states:

- Category 1: All designated uses are supported, no use is threatened
- Category 2: Available data and/or information indicate that some, but not all of the designated uses are supported;
- Category 3: There is insufficient available data and/or information to make a designated use support determination
- Category 4: Available data and/or information indicate that at least one designated use is not being supported or is threatened, but a TMDL is not needed

- Category 5: Available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed.

In classifying the status of their waters, states must report each waterbody in one or more category. Waters assigned to categories 4 and 5 are impaired or threatened; however, waters assigned to Category 5 represent waters on a state's Section 303(d) list. A state's Section 303(d) list is comprised of waters impaired or threatened by a pollutant, and needing a TMDL. Similar to Category 5, waters in Category 4 are also impaired or threatened; however, other conditions exist that no longer require them to be included on a state's Section 303(d) list. These conditions, which are referred to as subcategories of Category 4 in EPA's Integrated Reporting Guidance, are described below:

- Category 4a: TMDL has been completed
- Category 4b: TMDL is not needed because other required controls are expected to result in the attainment of an applicable WQS in a reasonable period of time
- Category 4c: The non-attainment of any applicable WQS for the waterbody is the result of pollution and is not caused by a pollutant. Examples of circumstances where an impaired segment may be placed in Category 4c include waterbodies impaired solely due to lack of adequate flow or to stream channelization.

2.8.3.5 Source Water Assessments

The Safe Drinking Water Act (SDWA) Amendments of 1996 require states to develop and implement Source Water Assessment Programs (SWAPs) to analyze existing and potential threats to the quality of the public drinking water throughout the state.

2.8.4 Pollutant Sources

Pollutants can be delivered to waterbodies from various point and nonpoint sources. Identifying and characterizing sources are critical to the successful development and implementation of a watershed plan and the control of pollutant loading to a stream. Characterizing and quantifying watershed pollutant sources can provide information on the relative magnitude and influence of each source and its impact on instream water quality conditions. Watershed specific sources are typically identified and characterized through a combination of generation, collection, and evaluation of GIS data, instream data, and local information. However, some common types of pollutant sources might be contributing to watershed problems, and this section discusses information available to characterize them.

2.8.4.1 Point Sources

The discharge of pollutants from point sources, such as pipes, outfalls, and conveyance channels is generally regulated through National Pollutant Discharge Elimination System (NPDES) permits.

2.8.4.2 Nonpoint Sources

Nonpoint source pollution, unlike pollution from industrial facilities and treatment plants, typically comes from many sources, not specific pipes or conveyances. Nonpoint source pollution is caused by rainfall or snowmelt moving over and through the ground, carrying natural and man-made pollutants and finally depositing them into surface waters. Surface water runoff represents a major nonpoint source in both urban and rural areas. Runoff from urban watersheds can deliver a variety of pollutants from roadways and grassed areas, and rural stormwater runoff

can transport significant pollutant loads from cropland, pastures, and livestock operations. Natural background sources like wildlife or geology (e.g., soils high in iron) can also contribute loadings and might be particularly important in forested or less-developed areas of the watershed. Additional nonpoint sources include on-site wastewater systems (septic tanks, cesspools) that are poorly installed, faulty, improperly located, or in close proximity to a stream and illicit discharges of residential and industrial wastes. This section discusses some common nonpoint sources characterized in watershed plans.

2.8.5 Waterbody Monitoring Data

A number of federal, state, local, and private entities monitor waterbodies across the nation. The EPA explains that monitoring data, including chemical, physical, and biological data, are critical to characterizing your watershed. Without such data, it is difficult to evaluate the condition of the waterbodies in your watershed. The waterbody data gathered and evaluated for the watershed characterization typically include flow, water quality (e.g., chemical concentrations), toxicity, and biological data. The following subcategories explain the types of data that are used for waterbody monitoring data.

2.8.5.1 Water Quality and Flow

This section discusses discuses water quality and flow characteristics of the watershed being analyzed. Data concerned with water quality and flow is meant to measure and track the health of a waterbody based on different sources of pollution. Without water quality data, it would be difficult to know the designated uses of the waterbody. The public needs to know if a waterbody is fishable, swimmable, or drinkable.

2.8.5.2 Biological Data

The EPA explains that aquatic life is affected by all the environmental factors to which they are exposed over time and integrate the cumulative effects of pollution. Therefore, biological data provide information on disturbances and impacts that water chemistry measurements or toxicity tests might miss. This makes this data essential for determining not only the biological health but also the overall health of a waterbody.

2.8.5.3 Geomorphological Data

Rivers and streams change in direct response to climate and human activities in the watershed. Increasing impervious surfaces like pavement, clearing forests and other vegetation, compacting soils with heavy equipment, and removing bank vegetation typically result in an adjustment in the pattern, profile, or dimensions of a river or stream. This information is helpful in analyzing the movement of sediment downstream from upland sources and channel banks.

2.9 Data Storage Needs and Solutions

Since this project revolves around creating a framework for a future watershed management plan, it is important that this information remains preserved and accessible for future use. Many choices exist for online data storage. Two main types of storage exist that are practical to this problem. These are cloud based storage and online data repositories.

An open access data repository is a free to use and access online archive for data storage and sharing. Open access data repositories differ from other institutional repositories in that open access refers to providing unrestricted access to its contents. Open access data repositories are typically used by large institutions such universities, as a means to provide academic resources

such scholarly articles, and journals. Open access repositories are becoming more popular as the concept of open access becomes more widespread. The term open access refers to a certain subset of free material with unrestricted access to its contents. In many cases open access repositories rely on the authors and others who submit and add to the repository, to have full control to disseminate and distribute their work freely. Issues open access repositories face often stem from copyright and distribution from publishers. It is not uncommon for publishers to place embargos or other restrictions on their materials. As online publication has become the prevalent means of distribution, the need to for long term storage becomes vital. Online data repositories allow for organized and widely accessible storage solutions

Other options also exist that are much simpler in concept than open access repositories. One such example is cloud based storage. Cloud based storage is essentially the storage of files on a server off site. These files are assessable to the host server via an internet connection. As long as users are aware of where the information is, they could technically access it freely. Often times cloud based storage is just storage of files; it is not usually as organized as data repositories. For example, they do not often contain metadata or other information except the files themselves.

3 Methodology

The main goal of this project was to locate, organize, and analyze data in order to provide a framework for a future watershed management plan for Coes Pond. Creating a watershed management plan is beyond the scope of our project so we focused on creating a framework for a watershed management plan, specifically steps one and two of The EPA Handbook for Developing a Watershed Management Plan. We intend this report to be useful for the CZTF, as well as future students and individuals who have an interest in continuing work on Coes Pond, who could benefit from using our report to develop a professional watershed management plan.

3.1 Objectives

The overall focus of our combined objectives was to gather information in such a way that would be beneficial to those who have the goal of improving the quality of Coes Pond. Each of our objectives involved planning and different research techniques which helped us obtain data for our project.

3.1.1 Objective 1: Categorizing Stakeholders

The first step in collecting data was to categorize where it was most likely to reside. The EPA handbook breaks stakeholders into three categories local, state and federal. From this we created a stakeholder map (Appendix – Water Resources IQP Workbook Excerpts), it organized each stakeholder into the level they belonged as well as gave us a way to keep track of all the stakeholders. We felt this was important because we needed to determine who would have relevant information. An effective way of gathering data was talking to local people and using what they had, it would have been hard to try and create all the information that we found on our

own. We determined that the most useful data could come from two of the three different levels of stakeholders: local, state, and federal. Different types of stakeholders offer different insights on the diverse types of data that exist. Our team worked mostly on the local level with stakeholders from the area such as: watershed associations, various non-government organizations (NGOs), municipal government, and other significant individuals. On the State level, we focused on gathering data from the Massachusetts Department of Environmental Protection (DEP). When looking into the federal level we determined that this project did not need to address all the laws and other federal regulations. The objective of the project was to create the framework, not expand into the legal aspects of a management plan. They could take a lot of time to fully understand and evaluate what they mean for the management plan at Coes Pond, it was a step we felt was too large for this project.

We located local watershed organizations and city agencies that likely to offer assistance. We found a list of possible stakeholders from all levels and began to research each group or person on the list. To organize the information we created a chart that would contain the name and contact information as well as a brief description of what they have done in the past with watersheds and a mission statement if we could locate one. In order to identify interested stakeholders, we sent out a generic email to a large list of groups and individuals. This list was meant to determine the level of interest in our project, as well as what local or state stakeholders would be able to help us with. In a few days we had received many responses and some stakeholders were willing to help our group while others were not interested. This was expected, we did not think every person on the list would be able to help us. Once we found a group of stakeholders that were willing to help we began to determine what relevant data they could offer.

On the local level we found a group of people with a shared interest in Coes Pond. The name of the group is the CZTF. After attending a few meetings, we identified individuals who could help us with our project. We considered these individuals to be high priority stakeholders due to a personal or professional commitment to improving Worcester watersheds, specifically Coes Pond. On the state level we contacted the DEP who helped us locate information as well as offered to assist in filling data gaps. After we categorized our stakeholders, the next course of action was to set up more meetings and conduct interviews in order to collect or locate the necessary data for our project.

Once we determined the stakeholders that were interested in Coes Pond we began to determine which ones would have the best watershed characterization information. These stakeholders could show bias but the data that they had would still be worth collecting and analyzing. The bias would be more in the aspect of what they want to see happen to the pond not so much with the data they can provide. Personal goals were noted and relevant data was pursued.

We found the best form of contact was through email, it gave us a written record of the conversation. Emails were very effective means to gather a lot of useful information as well as contacts. Each response started a new challenge of what information is useful and what can be left out. Anything that was from before 2005 was considered old data. We tried to only follow up with data that would contribute to a watershed management plan, and avoid data that was very old or not relevant to the project. Any data that did not have a direct impact on Coes was considered irrelevant to the project, we did consider some data that was from the same watershed and could have an effect on Coes. The Stakeholders with the most relevant data for the project

were later contacted and noted for a possible follow up interview. These interviews were a way for the team to record the conversations and collect information from the interviews.

During our interviews we asked if there were any other people they believed we should try and contact. This is called snowball sampling, it is somewhat effective in small scale research because there are a lot of connections with in the local level. A problem with snowball sampling is that not everyone can offer information that will help our project. Another down side to snowball sampling is that interviewees may not know of anyone else for us to talk to. (Biernacki, 1981)

3.1.2 Objective 2: Locating Data

A big challenge that arose after we categorized stakeholders was locating data from local and state resources. The team went about locating data through interviews, emails, research from online sources, and creating a dialogue with certain stakeholders that we knew could help us. We determined that we needed to communicate with stakeholders in order to successfully locate data as well as figure out specific stakeholder interests. This led us to interviews and email conversations.

Based on the EPA handbook, it was clear that creating a dialogue with stakeholders would help us locate data. Many of the stakeholders we reached out to were at the local level. Our team attended meetings of the CZTF, which allowed us to interact and observe important stakeholders and determine their background as well as their opinions about Coes Pond. At these meetings, we conversed with many stakeholders who would later be interviewed. Two of the stakeholders

were very interested in our project and offered to help us in our goal to locate watershed data. We created a dialogue with these stakeholders through emails and phone calls. Eventually, we set up site visits to discuss useful data that they had collected over the years.

Interviewing stakeholders ultimately led us to useful data. Besides physically locating data, conducting interviews helped us get a serious understanding of the stakeholders' interests in Coes Pond. This also helped us further evaluate and determine the context of the acquired data. We chose to conduct semi-standardized interviews because this type allowed us to ask scheduled questions of a formal interview, with the flexibility of an informal interview. This meant we were able to digress from a topic in order to pursue a relevant question to our project. We chose this type of interview to get the very best answers to the questions that would help us accomplish our goals.

We interviewed stakeholders on the local and state level. The questions asked included the following:

- What are your affiliations with Coes Pond?
- Have you worked on a Coes Pond project? If so which project and when was it?
- What's your personal interest in Coes Pond?
- What changes would you like to see with Coes Pond?
- Do you have access or knowledge to any exciting data on Coes Pond?
- Are there any other people we should be talking to?

These questions were designed to gain an understanding of the stakeholder's background, affiliation with Coes, and interests. However, the semi-standardized interview type allowed us to digress and ask different questions depending on the interview productivity. We also conducted a

series of informal email interviews where we asked similar questions. All questions we asked during interviews were asked in order to accomplish the desired goal of locating watershed data.

Another method for locating data is surveying the stakeholders and community members. Although surveys can have a number of advantages, our team decided surveys would not be useful for our project. This is primarily because most of the people who we would have created surveys for were a part of the CZTF. We had the ability to ask stakeholders directly so we decided that surveys would be an unnecessary method for locating data.

In our background, we explained that contacting state agencies can be helpful when trying to locate data. For our project, we contacted the department of environmental protection (DEP). The DEP has a number of branches concerned with the health of watersheds and can provide valuable primary data on Coes Reservoir. The last method of locating primary data sources was a search of internet databases such as google scholar, EBSCOhost, and Summon.

The last method of locating primary data sources was a search of internet databases such as google scholar, EBSCOhost, and Summon.

3.1.3 Objective 3: Inventorying Data

Following the guide within the EPA's Handbook for Developing Watershed Plans, we created an inventory spreadsheet in order to document our collected data. Then we created an inventory of known documents involved visiting with stakeholders in order to see what documents they had collected and filed away.

We began by looking at each document, and determined whether or not it was relevant to the topic of watershed management. We were mostly looking for information specific to Coes Pond, but any documents that contained information regarding the Tatnuck Brook watershed, or the Blackstone River watershed, or the City of Worcester were noted. At this phase, a brief description of the document, and of what types of data were in the document, was recorded. By performing this step, we were able to rule out certain documents, such as letters, or nondescript meeting minutes, that were not useful for our investigation. We were then able to determine what documents were likely to be useful to us, and began the next step. This involved collecting documents that appeared to contain information that would be useful to us, and documenting their contents with more detail, such that the information that would be useful to us, and to others.

For our purposes, we determined that a spreadsheet was sufficient. A database might have been more useful if we had found more data on Coes Pond, but for the scale of this project, an inventory spreadsheet was sufficient. In hindsight the database option would have been more useful, due to the multiple types of information that was inventoried.

Some of the data we were able to procure from contacts within state departments, such as the Department of Environmental Protection (DEP), was water quality testing data. Categories where data were not obtained were left blank in order to document what data is currently missing.

Documents that we found that were not particularly useful were still retained, as they may be useful to some other party. Certain items, however, were disregarded entirely if they seemed to have no importance. The types of items that were not included were flyers for previous events in the area, some town flyers that were not related to Coes Pond, and letters sent to or from coalitions or individuals. These types of documents were not of the variety that would provide any useful data regarding the pond or its surroundings.

After reviewing relevant documents, we added the following categories to our spreadsheet:

- Relevance to Coes Pond
- WMP requirements that can be fulfilled with the data
- Whether the information should be included in our report

Initially, we did a cursory inspection of documents borrowed from Lance McKee, and John Reed, members of the CZTF, but did not read them closely. All of the documents inspected were entered into our main spreadsheet on the page labeled CZTF Resources. Within the collection were news articles of some events that took place, letters sent to different coalitions, and business reports that did not directly correlate to the pond in question. Some of these items were merely documents of personal interest, or flyers, or informative newsletters. The documents we were interested in were those that were likely to contain relevant data, such as any news or

statistical information pertaining directly to Coes Pond, or reports on water quality testing performed in Worcester.

We began by noting the data, title, and source of each document. If it contained information regarding Worcester and its water, we took note. Of these documents, we read through their tables of contents, their abstracts, and introductions, and were able to determine whether or not they had relevant information. After looking at every document within the collection, and noting what contained the types of information we were looking for, we went back to physically obtain those documents, and look into them with much more detail. This meant going beyond scanning through the document, and reading it in its entirety to actually extract the data, so that we could include it within our report.

The first additional category; relevance to Coes Pond, indicated the scope of the report. If the document was focused on Coes Pond, it was more likely to contain data that we would find useful. If it was focused on the watershed as a whole, or on a neighboring body of water, it could still be useful to us. The second category would detail which of the data requirements, outlined in section 2.8 Analyzing Data, this document could potentially fulfil. The final category, whether or not the information should be included in our report, took into account details such as the age of the document (what year it was produced in), and what was determined in the previous two categories. This category is likely to be the least relevant to other parties, as our project requirements are not necessarily relevant to those of other individuals who make use of this information.

The EPA handbook suggests organizing inventory spreadsheets as follows:

- Document title
- Data
- Source/Author
- Description
- Web site (if available)

Similar to the EPA's suggestion, our inventory spreadsheet organized by the following categories:

- Year the document was produced
- Type of document (e.g., article, report, map)
- Document title (or the subject if no title was present)
- Description
- Source/Author
- Data

We decided to make the year that the document was produced our primary identifier due to the fact that most of the documents we were able to obtain were fairly old (from the early 2000s). Also, in addition to the name of the document, we included what type of document it was (such as a report, or article, etc.) because that would be a good identifier as to what type of data that could be obtained from a document. The description of the document was essentially what it was about, or generally what it contained, whereas the data component was what types of data, specific to the EPA's handbook requirements for data; Table 1, Table 2, and Table 3.

Although a number of the data was older than five years, it can still be used to determine what conditions existed in the past. It would not qualify for current data, but may be useful to some

who wish to observe trends in the waterbody, such as if there were a pattern of contamination recurring over the years. We found that the suggestions for categories outlined within the EPA's Handbook for developing Watershed Plans were sufficient for our spreadsheet, and thus followed their example. The year that the document was produced in is followed by what type of document it is, then by the title of the document, if it was present. A description of what is contained in the document, titled Contents of document, within our spreadsheet, gave a description of what it contains, followed by who produced the document. The final last category outlines what types of data are contained within that particular document.

The physical documents that we obtained for our project came from primarily two sources, with the exception of online resources that were given to us by email contacts. These documents were not in a public location, and are instead in possession of stakeholders, so it is difficult to make them widely available to the public. Hopefully, the documents may also change location, or be digitized at some point, if that is the desire of the owners. The documents came from Lance McKee and John Reed, two members of the CZTF. They are labeled in a way that makes them easy to find at their current location, because they were filed away by year, and type of document (e.g., newsletter, report, map).

By using a spreadsheet, we were able to organize our collected data within this report, and note what information was lacking, or where we were not able to find any data. By recording what types of data we do not have, it is easier to determine what type of data collection needs to be performed. More on this topic is available within the section 4.5 Summary of Analyzed Resources, in the findings section of our report.

3.1.4 Objective 4: Analyzing Data

After locating and inventorying our data, we had a general sense of what it contained. In the analysis phase, the team investigated the data more thoroughly and compared it to Table 1, Table 2, and Table 3, which were excerpted from Chapter 5 in the EPA's handbook for developing a watershed management plan.

Our team analyzed data by going through every item in our inventory and reading it. This process allowed us to determine the value of all documents listed in our inventory. Once we had read through every document in our inventory, we created a spreadsheet titled CZTF resources. This spreadsheet displays the document where we found data, the type of data it contained, and the category to which the data belongs with respect to Table 1, Table 2, and Table 3.

We used Microsoft Excel to display our analysis of data because EPA uses and recommends using Excel or other spreadsheet programs for this reason. We used these tables as a guide because they show the five data categories needed for watershed characterization including; physical and natural features, land use and population characteristics, waterbody and watershed conditions, pollutant sources, and waterbody monitoring data. Each of these categories contains different types of data that are crucial for producing a WMP. Analyzing our data allowed us to provide a framework that would simplify the required tasks for producing a Coes Pond WMP. The framework described here can be found in our findings chapter under the section titled summary of analyzed resources.

3.1.5 Objective 5: Provide Recommendations for Data Storage

To determine a viable solution for the data storage needs of this project, the factors considered were accessibility, the size or amount of data that needs to be stored, price, and long term storage ability. Many of these factors must be considered due to the types of stakeholders involved in the project. Most of the actively involved stakeholders are largely local non-governmental organizations, such as non-profit watershed associations. These stakeholders are typically restricted due to a lack of funding and rely heavily on volunteers.

Since accessibility was considered a primary factor, it was determined to use an online resource as a means of data storage. Another important consideration for accessibility is how popular, or how widely used is the program. As the data is collected and ultimately archived it important to understand the scope of the information collected. The amount of data that needs to be stored is an important factor for determining a final solution.

Although this project only covers some of the preliminary steps of developing a watershed management plan, it also encompasses collecting data for later use for other purposes. This requires guaranteed long term storage. Along with long term storage capabilities, cost is also a major governing factor. Since most of the time and support is an effort of volunteers, cost is a major consideration.

3.2 Deliverables

Our report supplied three important deliverables that accomplished the goal of our IQP, which was to locate, organize, and analyze data in order to provide a framework for a watershed management plan. The first deliverable is our report itself. Our paper explains the history of Coes Pond, its value to the area, the reasons for its need of a watershed management plan, and what information is out there that people could use to formulate said management plan. The second deliverable is our Excel workbook titled WRIQP Inventory spreadsheet. Our Excel spreadsheets contain detailed information of all data we found during the length of our project. This information is categorized in headed columns so that the researcher can navigate through with ease in order to find details about said information. Details such as: where the information is located, who has it, what it is useful for, date it was produced, and so on. Our third deliverable is a recommendation of where all data on this subject can be stored electronically. One of the main needs of the CZTF was to have a central storage hub of all data on Coes Pond. To see that this need could become a reality our IQP team worked with a library technician to determine what type of storage unit would best suit their needs. Ultimately what this project delivers is a framework to create and implement a future watershed management plan for Coes Reservoir.

4 Findings & Recommendations

The following sections represent the findings of our project, and our framework to facilitate a Coes Pond watershed management plan.

4.1 Categorizing Stakeholders

Categorizing stakeholders required the creation of a stakeholder map. It consists of all the names of our stakeholders as well as what organization they are a part of which divided them into the levels. The map was important because it was a way to display what stakeholders we found. It also gave us a place to store all the contact information and other useful information from the stakeholders.

Local stakeholders, or the local community members to large watershed associations, were able to offer us personal letters and also contacts to stakeholders at other levels. Our main contacts for the local level were Lance McKee, John Reed, and Peter Coffin. We also contacted the Worcester DPW and the DPH in Worcester.

One of the first local stakeholders we talked to was Lance Mckee, a member of the CZTF was very passionate in helping Coes Pond improve. Mr. Mckee is connected to Coes Pond with personal interests, and over time we began to understand his hopes and goals for Coes. The data he supplied us was helpful and the task force became a good place to acquire new resources.

While at one of the meetings for the CZTF we were able to meet with John Reed, who is a member of the Knights of Columbus. John was able to offer a box of letters, and other

documents, that we searched through for information. These documents were analyzed and displayed in the inventory spreadsheet we created. Mr. Reed indicated that he would like to see the pond become a useable beach in the summer. When talking to him he expressed his interest in seeing Coes Pond become a popular place again. This was a trend in the conversations we had with other stakeholders.

We met with another individual who was a member of the Blackstone head water coalition. We discussed our project with him and he was able to give documents on the water body testing from past years. He also was able to discuss how water flows through the watershed which was helpful when looking for the problems that are occurring at Coes Pond.

One contact that we interviewed worked on a management plan for a waterbody, and we believed that they would be capable of offering useful insight into the process for our project. After exchanging a few emails we set up a formal interview. The interview helped us understand the sheer size of a management plan. During the interview, our contact stated "our projects were large and we used the help of outsourcing some of the work to consulting companies" (Personal Communication, Interview, 2014). This project will be able to not only help with a future management plan for Coes but it can also be used for many different locations. The steps that we used can be repeated for almost any watershed. The development of a management plan takes a lot of time and effort to go from start to finish.

We also interviewed a contact who works for the city Department of Public Works (DPW). He works in the sanitation department for the city, when talking to him we tried to find data on

beach testing for E.coli and other bacteria. He was able to give us the name of another individual who works for the Department of Public Health (DPH), and told us that this contact would be able to help us with the health and safety aspects at Coes Pond. He was also able to provide GIS mapping for the area around Coes Pond that could help us with our project. During the interview, we asked our contact what he hoped to see Coes Pond like in the future. His response was "I hope to see it back to the way it was before, with people going there and using it as it was intended" (Personal Communication, 2014).

Our contact from the DPH works with the bathing water testing, and Coes Pond falls under the bathing water category. Our interview with this individual led to us obtaining spreadsheets for water quality testing for Coes Pond. During the interview, he informed us that the maintenance crews that work at Coes Pond were told that there was a problem with geese and that the beach needed to be cleaned almost every day to keep the E.coli levels low.

The stakeholders that we found from the local level were able to help us delineate the total size for a watershed management plan. These stakeholders had an interest in making Coes Pond a place that was is used by the community and that is a place people will come to regularly.

One of our contacts at the state level was a worker from the DEP, this contact, was able to send us test results from 2005 as well as some news articles. She also sent us reports for the Blackstone River Watershed, which were helpful but did not have too much specific data on Coes Pond.

At the federal level, we were not able to find many contacts outside the EPA. The data that pertained to this project mainly revolved around the state and local levels. In the next steps of building a full watershed management plan, the federal level would come more into play. There are federal laws and regulations that need to be looked into and made sure they are followed.

4.2 Watershed Data Located for Coes Pond

Much of the data from state and local sources can be found online and most of the stakeholders we interviewed referred us to websites. State sources like the EPA and DEP have their own websites which provide a wide range of watershed data. Our project used the EPA site not only for locating data but for guidance as well. The DEP had several branches concerned with watershed health including: Fisheries & Wildlife, Recreation & Conservation, Environmental Protection and Agriculture. All of these branches contained useful information for our team to better understand watersheds. The Worcester Parks and Recreation Department had reports and management plans specifically for Coes Pond which contained useful and current information. Ultimately, interviews were more helpful in gaining an understanding of the stakeholder and general watershed knowledge than locating data. Conducting our own individual research was a successful tool in locating data. The data located is referenced in both our paper in the summary of analyzed resources section as well is in our Excel workbook under the sheet titled CZTF Resources.

4.3 Inventoried data

The completed inventory of physical documents is contained within our workbook titled “WPI Water Resources IQP Inventory Workbook,” on sheet one, titled “Coes Zone Task Force

Resources." The resulting spreadsheet was constructed using the guidelines within the EPA's Handbook for Developing Watershed Plans to Restore and Protect our Waters. There are multiple sheets within the main workbook. The first sheet, Coes Zone Task Force Resources, contains the information found in hardcopies of reports that were filed away at two of our stakeholders' residences. The second sheet, Interview Summaries, contains the organized responses from interviewees that. The third sheet, MassGIS Layer Topic Information contains GIS data gathered from MassGIS. Each layer is accompanied by a link to the MassGIS site that shows the information contained within each layer, as well as a brief description of the topic, the year the data was produced, and what type of data the layer contains. The fourth sheet, Stakeholder Map, is a map of organizations in the Worcester County area that perform work on Coes Pond, or its watershed, have relevant data pertaining to the quality of Coes or its watershed, or are likely to have an interest in assisting with the improvement of Coes.

We were able to find physical documents from a few sources, including contacts within the DEP, and members of the CZTF. From our contacts in the DEP, we were able to obtain some water quality testing results for the Blackstone River watershed, and some water quality testing reports for Coes Pond. From the CZTF, we were able to meet with two stakeholders who had old documents relating to Coes Pond and watersheds like the Blackstone River watershed, and the Tatnuck Brook watershed. We recorded brief descriptions, along with titles and dates, of the documents and put them into our spreadsheet. We left out a lot of documents such as news clippings, letters/emails, and meeting minutes because we determined that they would not be useful either to us, or to anyone with the intention of gathering data to build a watershed management plan. What we did take from these physical records was maps, reports from other

WPI project groups, reports from major contractor companies, and from other individuals who had previously done studies on Coes Pond or related watersheds.

In addition to missing data, we also found a number of documents that were essentially of little or no use for the development of a watershed management plan. These documents were either too generalized to a large watershed, or had no analytical data within them. Certain documents were more focused on how someone may go about collecting test data, or why it was important. Additionally, the majority of the documents contained within personal collections were beyond 5 years old. Some of this data we decided to include for the sake of reference, or simply because of a lack of data, but for the others, we deemed that they were too old to be of any actual use and would end up causing more harm than help if they were included. Old testing results, especially when the method of data collecting is not explained, can be unreliable because methods and standards for testing change over time. The data might not only represent old problems, but how we test may be so different that it would take too much work to actually compare current and old data to the point where it is no longer helpful.

For the documents that we did include, their data within the first spreadsheet, containing information on the hardcopy documents, was organized by the following categories:

- Year the document was produced
- Type of document (e.g., article, report, map)
- Document title (or the subject if no title was present)
- Description
- Source/Author
- Data
- Relevance to Coes Pond
- WMP requirements that can be fulfilled with the data
- Whether or not the information should be included in our report

The year that the document was produced holds high level of value in determining whether or not information is useful because of the fact that standards for testing change over time. Because of this distinction, we decided to organize the first sheet of the spreadsheet primarily by year, in descending order, starting with the most recent documents. The next column contained the type of document, such as a map, or a report, which will tell the user what sort of format to expect. This is useful for those who are looking for specific types of information sources such as projects, commercial reports, or maps. Following the type of document is the title of the document, and then a description of the contents of the document.

For the final three categories; relevance to Coes Pond, WMP requirements that can be fulfilled with the data, and whether or not the information should be included in our report, we took a slightly deeper look into the documents to determine whether it would be beneficial to include their data within our report. The year the item was released, the data within the document, and

the source or author of the document were determining factors for whether or not the document was likely to be useful. We mostly wanted newer documents that had analytical data on the physical and natural features of Coes, land use and character population characteristics, waterbody conditions, pollutant sources, and waterbody monitoring data. If the document appeared to have any of this information, we would take a deeper look into it and take note of what category the data within the document fulfilled. This was a simpler task for the survey data as what type of data it had was very clearly labeled, making the process only really necessary for the hardcopy documents that did not contain survey data. We came to realize that most of the documents are not suitable to be included in our report. This is demonstrated by looking under the "What types of data are recorded?" category on the spreadsheet. In some cases, there was little to no data that seemed useful, and this is represented by a lack of a description of the data we could include, or an indication that there was none. In other cases, the document did not offer the type of data we were looking for, but we deemed that it could be useful as a reference because of the type of information it did contain. This was also true in the case of very old documents where the data is no longer viable, but it can still potentially be used as a sort of guide to gathering data for future work.

Currently, the documents will remain with the stakeholders who provided them for us, aside from the online materials we received from contacts within the DEP. At this point in time, there is no central repository for the hardcopy data; possible solutions for this problem are discussed in section 4.7 Recommendations for Data Storage in more detail, and for the sake of privacy, the documents can be located by an interested party by contacting the CZTF.

As can be seen in the second sheet of the inventory spreadsheet, there are a number of blanks within our data. These data gaps will need to be filled in at some point. The inventory datasheet mostly displays data on physical and natural features, some watershed and waterbody conditions, and land use and population characteristics. On closer inspection, the documents containing waterbody and watershed conditions mostly consist of water quality standard testing, and these documents are described as being for the Blackstone River watershed, and not specifically for Coes. We were able to find a number of maps that outline some of the land use and population characteristics since there have been plans in the past 10-15 years to renovate the Coes beach area. These maps show likely changes and current landmarks on the pond. In addition, there is data on percentages of land use from different factors such as forests, and living quarters. There is more data on this within the findings portion of the analysis. There is also some data on the physical and natural features of the lake, specifically regarding the soils and climate and topography of the lake contained within maps, and some reports regarding the dam project and renovation projects.

4.4 Inventoried GIS Data

With the majority of geographic information systems (GIS) findings coming from the Massachusetts Office of Geographic Information (MASSGIS) database, the GIS findings are organized following the system similar to that used by MASSGIS. MASSGIS categorizes their data layers by type and topic. The category “Type” refers to a broader classification of data. The “Topic” category refers to a more specific subset of the “Type” category. Specifically the “Type” categories as defined by MASSGIS are listed in bold font with the corresponding “Topic” listed as a subset in Table 4 – MassGIS Datalayers Classifications, below.

Table 4 – MassGIS Datalayers Classifications

Image
Ortho Imagery
Elevation and Bathymetry
Environmental Analysis
Scanned Reference Maps
Vector
Scanned Reference Maps
Census/Demographic Data
Coastal and Marine Features
Conservation/ Recreation
Cultural Resources
Environmental Monitoring
Indexes
Infrastructure
Transportation
Other Facilities and Structures
Physical Resources
Land Use/Land Cover, Geological/Geophysical, Atmospheric
Elevation and Derived Products
Inland Water Features
Political and Administrative Boundaries
Political/Administrative Boundaries
Regulated Areas
Regulated Areas
Miscellaneous
Miscellaneous

In addition to the categories of "Type" and "Topic", the GIS files were also organized by year, author, and the actual file name. Following our earlier methods, the GIS findings were organized following the chosen categories in a spreadsheet. Using a spreadsheet allows for the GIS files to be accessed through linked instead of being physically located in the spreadsheet. This was chosen since GIS files tend to be stored and located in online accessible databases, and also due

to the GIS files commonly requiring a large amount of storage space. As a result, we created an organized and searchable spreadsheet with relevant links to GIS files that can be easily accessed and downloaded.

Although very few relevant GIS files were found from stakeholders or other websites, other valuable pieces of data were located. This data consisted mostly of historical maps pertaining to Coes Pond and the surrounding watersheds. These maps show likely changes and current landmarks on the pond. In addition, there is data on percentages of land use from different factors such as forests, and living quarters. There is also some data on the physical and natural features of the pond specifically regarding the soils, climate, and topography of the lake contained within maps, and some reports regarding the dam project and renovation projects. This data allows for the potential for review of historical data in the area. The maps could be uploaded and turned into new datalayers.

The MassGIS files that we inventoried for our project in the Excel file that accompanies this report are a collection of over two hundred individual data layers pertaining to the Massachusetts and surrounding region. The data layers we examined were not classified by direct relevance to Coes Pond, but rather relevance to the area. This was done because the scope of each data layer could be used uniquely to identify or create specific correlations to Coes Pond at the stakeholder's discretion. The GIS findings were then organized into tables by their Type and Topic, and organized within that by their year of creation, author and title of file. The files organized in these tables were categorized as relevant to the project. As a result many of identified datalayers are not included due to not containing data relevant to Coes Pond or the

surrounding area. Other discarded datalayers contained old or out of date data, or the data is too large of a scale for use in the Coes Pond Area. The relevant data layers are organized below in Tables 5-12.

Table 5 – GIS Image Data

Image Data		
Ortho Imagery (Aerial photography)		
Year	Author	File Name
2015	MassGIS	USGS Color Ortho Imagery (2013/2014)
Elevation and Bathymetry		
Year	Author	File Name
2002/2012	MassGIS	LiDAR Terrain Data
2005	MassGIS	Digital Elevation Model and Shaded Relief (2005)
2005	MassGIS	Digital Elevation Model (1:5,000)
2005	MassGIS	Shaded Relief (1:5,000)
Environment Analysis		
Year	Author	File Name
2005	MassGIS	Crop Evapotranspiration and Potential Evaporation Grids
2007	MassGIS	Impervious Surface
Scanned Reference Maps		
Year	Author	File Name
1995/ 2001	MassGIS	USGS Topographic Quadrangle Images
2012	MassGIS	USGS 1:24,000 Surficial Geology Topographic Base Map

Table 6 – GIS Vector Data

Vector Data		
Census/Demographic Data		
Year	Author	File Name
2012	MassGIS	USGS 1:24,000 Surficial Geology Topographic Base Map Images
2010	MassGIS	Datalayers from the 2010 U.S. Census
Year	Author	File Name
2009	MassGIS	Areas of Critical Environmental Concern
1997	MassGIS	Canoe Trips and Access Points
2014	MassGIS	DCR Roads and Trails

Table 7 – GIS Vector Data Continued

2014	**MassGIS**	**Office of Fishing and Boating Access Sites**
2014	MassGIS	Protected and Recreational Open Space
2012	MassGIS	Protected and Recreational Open Space
2001	MassGIS	Tracks and Trails
2008	MassGIS	NHESP Priority Habitats of Rare Species
2008	MassGIS	NHESP Estimated Habitats of Rare Wildlife
Environment Monitoring		
Year	Author	File Name
1997	MassGIS	Insect Infestation (BUGS)
1997	MassGIS	MassDEP DWM Monitoring Stations
Indexes		
Year	Author	File Name
2013	MassGIS	LiDAR Terrain Data Index
2012	MassGIS	Surficial Geology (1:24,000) Status Index
2015	MassGIS	USGS Color Ortho Indexes (2013/2014)
1996	MassGIS	UTM Grid and Points

Table 8 – GIS Infrastructure Data

Infrastructure Data		
Transportation		
Year	Author	File Name
2012	MassGIS	Airports
2014	MassGIS	MassDOT Roads
Other Facilities and Structures		
Year	Author	File Name
2014	MassGIS	Building Structures (2-D, from 2011-2013 Ortho Imagery)
2007	MassGIS	Colleges and Universities
2012	MassGIS	Dams
2014	MassGIS	DCR Pools
2005	MassGIS	MWRA Water/Sewer Service Areas
2009	MassGIS	Public Utility Service Providers
2014	MassGIS	Public Water Supplies

Table 9 – Physical Resources Data

Physical Resources Data		
Land Use/Land Cover, Geological/ Geophysical, Atmospheric		
Year	Author	File Name
2007	MassGIS	Aquifers
2002	MassGIS	Land Use (1951-1999)
2009	MassGIS	Land Use (2005)
2003/ 2007	MassGIS	Land Use Summary Statistics
2012	MassGIS	NRCS SSURGO-Certified Soils
2005	MassGIS	Public Water Supply Service Territories
2012	MassGIS	Surficial Geology (1:24,000)
1996	MassGIS	U.S. EPA Designated Sole Source Aquifers
1999	MassGIS	U.S. EPA Ecoregions
Elevation and Derived Products		
Year	Author	File Name
2003	MassGIS	Breaklines (1:5,000)
2005	MassGIS	Breaklines and Mass Points (2005)
2003	MassGIS	Contours (1:5,000)
2003	MassGIS	Digital Terrain Model (DTM) Files
2003	MassGIS	Elevation Points (1:5,000)
2006	MassGIS	Quabbin Reservoir Bathymetry
Inland Water Features		
Year	Author	File Name
2007	MassGIS	Drainage Sub-basins
2014	MassGIS	MA DFW Coldwater Fisheries Resources
2003	MassGIS	Major Drainage Basins
2000	MassGIS	Major Watersheds
2010	MassGIS	MassDEP Hydrography (1:25,000)
2014	MassGIS	MassDEP Wetlands (1:12,000) Change
2007	MassGIS	National Wetlands Inventory
2013	MassGIS	Surface Water Supply Watersheds
2013	MassGIS	USGS Major Ponds and Major Streams

Table 10 – Political and Administrative Boundaries Data

Political and Administrative Boundaries Data		
Political/Administrative Boundaries		
Year	Author	File Name
1998	MassGIS	Adjacent States' Town Boundaries
2014	MassGIS	Community Boundaries (Cities and Towns)
2004	MassGIS	Community Boundaries (Cities and Towns) from Survey Points
2014	MassGIS	County Boundaries
2006	MassGIS	MassDEP Regions
1991	MassGIS	State Outlines

Table 11 – Regulated Areas Data

Regulated Areas Data		
Regulated Areas		
Year	Author	File Name
2014	MassGIS	FEMA National Flood Hazard Layer
1997	MassGIS	FEMA Q3 Flood Zones from Paper FIRMs
2011	MassGIS	Ground Water Discharge Permits
2013	MassGIS	MassDEP 2012 Integrated List of Waters (305(b)/303(d))
2015	MassGIS	MassDEP BWP Major Facilities
2013	MassGIS	MassDEP Land Disposal of Solid Waste
2012	MassGIS	Non-Potential Drinking Water Source Areas
2013	MassGIS	Surface Water Supply Protection Areas (ZONE A, B, C)
2010	MassGIS	Title 5 Setback Areas

Table 12 – Miscellaneous GIS Data

Miscellaneous		
Miscellaneous		
Year	Author	File Name
2013	MassGIS	Geographic Place Names

4.5 Summary of Analyzed Resources

Analyzing gathered data for a WMP is an extensive but important process because once enough data has been gathered and analyzed, the information can then be used to develop the plan. Our project aimed to simplify this process by organizing sources containing useful data and explained the value of the data in relation to watershed management. This section of our findings describes the data we found and how the data correlates to Table 1 , Table 2, and Table 3, from the EPA handbook previously shown in our background. These tables display the different types of data needed to produce a WMP. Our project involved locating, organizing, and analyzing these different types of data from these tables for Coes Pond with a goal of making it easy for anyone to find and use this data for future watershed management purposes.

Each of the five main categories from these tables are comprised of sub-categories which involve more specific examples of the types of data needed to fulfil the requirements of a WMP. The following sections display the characterization of our data within their respective categories.

4.5.1 Physical & Natural Features

The data required for physical and natural features section is meant to better define the watershed. Many sources we investigated had data for physical and natural features of the Coes Reservoir. The following sections (4.5.1.1 – 4.5.1.7) break down our data findings for every subcategory in the physical and natural features section.

4.5.1.1 Watershed Boundaries

In the subcategory for watershed boundaries, the data include two maps from Patch & Coes Reservoir Management Study (Baystate Environmental Consultants, Inc., 2002) and Coes Pond Master Plan (City of Worcester Department of Public Works and Parks, 2005).

The former was produced by Baystate Environmental Consultants (BEC), Inc. in 2002. This company is a professional engineering consulting company. In their report, BEC Inc. provided a map, Figure 6 – Contributing Sub-basin Map - Coes Reservoir, which displays geographic boundaries, topographic information, and spatial relationships to different waterbodies. This source also provides a written description which delineates 8 different storm-water drainage features at Coes and describes the problems with them as well as potential solutions.

The latter source was produced Worcester's Parks and Recreation department. The Coes Pond Master Plan, produced in 2005, contains a more modern map which also displays geographic boundaries, topographic information, and spatial relationships. Both maps are useful because they help to define the features of the watershed.

4.5.1.2 Hydrology & Topography

Hydrological data is concerned with the movement of water. In the case of watershed management, movement of water is important because polluted water can travel to non-polluted water. Topographical data is meant to identify elevated terrain in order to track movement of runoff. In the subcategories for hydrology and topography, we found a few different sources of data which provided us with useful maps that display both types of data. The map mentioned in

the previous section on watershed boundaries, Figure 6, identified locations of waterbodies and displayed areas of elevation around Coes Pond which falls into both categories of hydrology and topography.

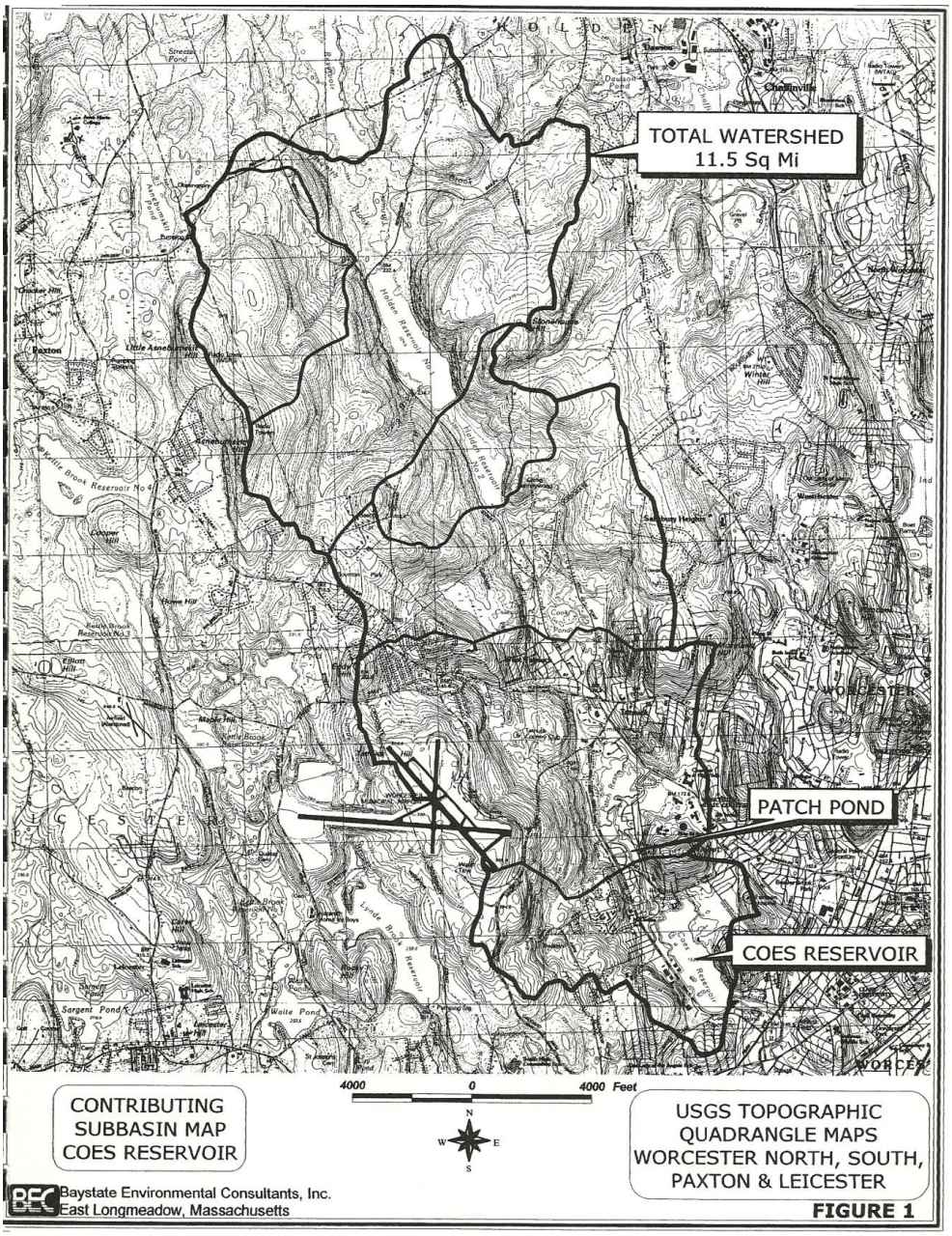


Figure 6 – Contributing Sub-basin Map - Coes Reservoir

(Baystate Environmental Consultants, Inc., 2002)

4.5.1.3 Soils

For data on soils we could only find one document that contained useful data on Coes Reservoir, the City of Worcester Open Space and Recreation Plan (Worcester Department of Public Works & Parks, Worcester Planning & Regulatory Services, 2013). This plan was produced by the Worcester Parks and Recreation department in 2013. The data includes the four types of soil that are common in Worcester. It also explains the characteristics of each type of soil. This was useful because different types of soil can have higher erosion rates or poor drainage. However, the data from this source was focused on all of Worcester and not Coes Pond specifically. Some research will need to be done in order to determine which of the four types of soil the Coes Pond Area is comprised of so as to better define the watershed and its features.

MassGIS also contained some data on soils in Worcester; however, soil data on Coes and the surrounding area was not included and therefore MassGIS data on soils was not useful for this project.

4.5.1.4 Climate

Climatological data is used to discover patterns in weather that can contribute to causes of impairment in a watershed. The NCDC provides past to present climatological data on topics such as: air temperature, precipitation, sky cover & clouds, water, weather type, and wind (National Climatic Data Center). Data from these categories can be tracked and used to explain possible sources of pollution. The following table (Table 13) from the NCDC is an example of the types of data recorded.

Table 13 – Climatological Data Worcester Airport

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data, and Information Service

Record of Climatological Observations
These data are quality controlled and may not be identical to the original observations.

Station: **WORCESTER REGIONAL AIRPORT, MA US**
Observation Time Temperature: Unknown Observation Time Precipitation: 2400 Elev: 10

Preliminary	Year	Month	Day	Temperature (F)			Precipitation(see **)					Evaporation		Soil Temp		
				24 hrs. ending at observation time		at Observation	24 Hour Amounts ending at observation time				At Obs Time	24 Hour Wind Movement (mi)	Amount of Evap. (in)	4 in depth		
				Max.	Min.		Rain, melted snow, etc. (in)	Flag	Snow, ice pellets, hail (in)	Flag	Snow, ice pellets, hail, ice on ground (in)			Ground Cover (see *)	Max.	Min.
	2015	1	1	30	13		0.00		0.0							
	2015	1	2	34	26		0.00		0.0							
	2015	1	3	30	20		0.58		2.2							
	2015	1	4	47	30		0.42		T							
	2015	1	5	40	10		T		0.0							
	2015	1	6	13	7		0.03		0.6							
	2015	1	7	19	7		T		T							
	2015	1	8	17	-6		0.00		0.0							
	2015	1	9	28	16		0.09		2.1							
	2015	1	10	18	8		0.00		0.0							
	2015	1	11	27	6		0.00		0.0							

(National Climatic Data Center, 2015)

This table displays quantitative data on temperature, precipitation, evaporation, and soil temperature at the Worcester Regional Airport which is just next door to Coes Reservoir. The data from the NCDC can be used to follow climatological events near Coes that lead to pollution at the reservoir.

4.5.1.5 Habitat

One focus of data under habitat includes identifying areas for conservation, protection, and restoration. The Coes Pond Master Plan (City of Worcester Department of Public Works and Parks, 2005), produced in 2005 identifies areas for conservation, protection, and restoration. These areas include; the old Coes Knife property, Coes Beach and Bathhouse, and the former Knights of Columbus site.

4.5.1.6 Wildlife

We found some data on wild life at Coes Pond. The mass.gov website has information on fisheries throughout different cities and towns in Massachusetts. Table 14, depicted below, shows a selection of a table from the mass.gov site. The entire table shows the city or town the waterbody is in and the waterbodies which are stocked with trout. As shown in this excerpt of the Massachusetts trout stocked waters, Coes Pond is a trout stocked waterbody

Table 14 – Trout Stocked Waters; MA

Town	Stocked Waters
WORCESTER	Lake Quinsigamond, Coes Pond, Bell Pond

(Executive Office of Energy and Environmental Affairs).

The Worcester Open Space and Recreation Plan (Worcester Department of Public Works & Parks, Worcester Planning & Regulatory Services, 2013) completed in 2013 provides a section on fisheries and wildlife. This section contains a table which lists all threatened and endangered species in Worcester. This data is useful because it can be used by anyone in Worcester creating a watershed management plan. The data on wildlife at Coes Reservoir is scarce, however, Table 15, below, could be used to investigate endangered species, if any, at Coes.

Table 15 – Rare, Threatened and Endangered Species in Worcester

Table 4-6 Rare, Threatened and Endangered Species in Worcester

Scientific Name	Common Name	MESA status	Most Recent Observed
Accipiter striatus	Sharp-shinned Hawk	SC	1880
Adlumia fungosa	Climbing Fumitory	SC	1938
Ambystoma opacum	Marbled Salamander	T	2012
Ammodramus savannarum	Grasshopper Sparrow	T	2009
Asclepias purpurascens	Purple Milkweed	E	1879
Bartramia longicauda	Upland Sandpiper	E	1960
Boechera laevigata	Smooth Rock-cress	SC	2012
Carex lenticularis	Shore Sedge	T	1933
Cicindela purpurea	Cow Path Tiger Beetle	SC	Historic
Eacles imperialis	Imperial Moth	T	Historic
Elymus villosus	Hairy Wild Rye	E	2009
Falco peregrinus	Peregrine Falcon	E	2010
Hydrophyllum canadense	Broad Waterleaf	E	1934
Lygodium palmatum	Climbing Fern	SC	1879
Myotis sodalis	Indiana Myotis	E	1937
Ophioglossum pusillum	Adder's-tongue Fern	T	1933
Penstemon hirsutus	Hairy Beardtongue	E	1890
Platanthera flava var. herbiola	Pale Green Orchis	T	1939
Potamogeton vaseyi	Vasey's Pondweed	E	2007
Pyrrhia aurantiago	Orange Swallow Moth	SC	2012
Satyrium favonius	Oak Hairstreak	SC	1992
Sorex palustris	Water Shrew	SC	1880s
Terrapene carolina	Eastern Box Turtle	SC	1992

E ■ Endangered
T ■ Threatened
SC ■ Special Concern

(Worcester Department of Public Works & Parks, Worcester Planning & Regulatory Services, 2013)

4.5.1.7 Summary of Physical & Natural Features

Data on physical and natural features are important because they better define the Coes Reservoir watershed boundaries and provide a straightforward understanding of the watershed features. Anyone could use the data in the physical and natural features section to gain a better

understanding of the watershed characteristics. Although there were some useful findings in this section, more work, especially for climatological data, could be done to better understand and characterize Coes Pond.

4.5.2 Land Use & Population Characteristics

This section discusses data and information for determining the distribution of land use in the Coes Reservoir area. Land uses are an important factor which can influence the physical conditions of the watershed as well as provide a basic understanding of the different sources at work in the area. Subcategories which comprise the land use and population characteristics section include: land use & land cover as well as existing land management practices. The following sections (4.5.2.1 – 4.5.2.4) describe the data we obtained for this section.

4.5.2.1 Land Use & Land Cover

For the subcategory concerning land use and land cover, we found a table from the Patch and to Coes Reservoir Management Study (Baystate Environmental Consultants, Inc., 2002). This document provides a table of land use in watershed of Coes Reservoir. The table is broken down into a ratio that displays the percentage of land uses per acre of land. For example, in 2002, cropland for the Coes Reservoir watershed was 0.1% per 1.6 acres. This table also provides the percentage per acre of total impervious surfaces. This is important because one could use this information to estimate factors of non-point source pollution based on the percentage of impervious surfaces. Although outdated, we determined this data to be useful because it provides a general idea of land uses of in the Coes Reservoir area, these data are in Table 16.

.

Table 16 – Land Use Survey in Watersheds of Coes Reservoir and Patch Pond

Table 2. Land Use Summary in Watersheds of Coes Reservoir and Patch Pond				
Land Use Category	**Coes Reservoir**		**Patch Pond**	
	acres	**percent**	**acres**	**percent**
Cropland	1.6	0.1	1.6	0.1
Pasture	5.9	0.2	5.9	0.4
Forest	1001.3	39.6	631.8	38.1
Wetland	3.9	0.2	0	0
Mining	0	0	0	0
Open Land	46.6	1.8	46.6	2.8
Recreation	69.6	2.8	60	3.6
Spectator	30.6	1.2	30.6	1.8
Water Based	7.4	0.3	0	0
Multi-family Residential	53.7	2.1	14.6	0.9
Residential <1/4 acre	678.7	26.8	494.9	29.8
Residential 1/4-1/2 acre	94.4	3.7	36.8	2.2
Residential >1/2 acre	11.0	0.4	10.7	0.6
Commercial	68.5	2.7	33.7	2.0
Industrial	23.7	0.9	0	0
Open Urban	112.7	4.5	72.8	4.4
Transport	192.8	7.6	183.7	11.1
Waste Disposal	0	0	0	0
Water	125.8	5	35.1	2.1
Totals	2528.2	100	1658.8	100
Total Impervious Surface	734	29.2	530	27.4

source: MassGIS 2002. Watershed areas for both ponds are identified as the "critical watersheds" below Cooks Pond.

(Baystate Environmental Consultants, Inc., 2002)

MassGIS provided the best and most current data on land uses in the Coes Reservoir area. Figure 7 – Worcester, MA; Coes Pond Watershed Area Land Use Map 2005, below, depicts the different land uses in the Coes area today. The two outlined areas represent the lower and upper Coes Sub-basins of the watershed that contains Coes Pond, as labeled in the figure. The majority of land uses in the Coes Reservoir region are high density residential. Other uses include spectator & water-based recreation, commercial uses, and forest.

This map can be used to help determine land uses that could be contributing to pollutant loads at Coes. For example; the most prominent land use in the area seems to be high density residential. That information could be used to make assumptions about vegetation problems at Coes Pond, such as if the majority of the community used fertilizers for their gardens, grass, or flowers, which results in nutrient loads that can be transferred to Coes Pond via stormwater runoff, and ultimately cause an overgrowth of vegetation at in the pond.

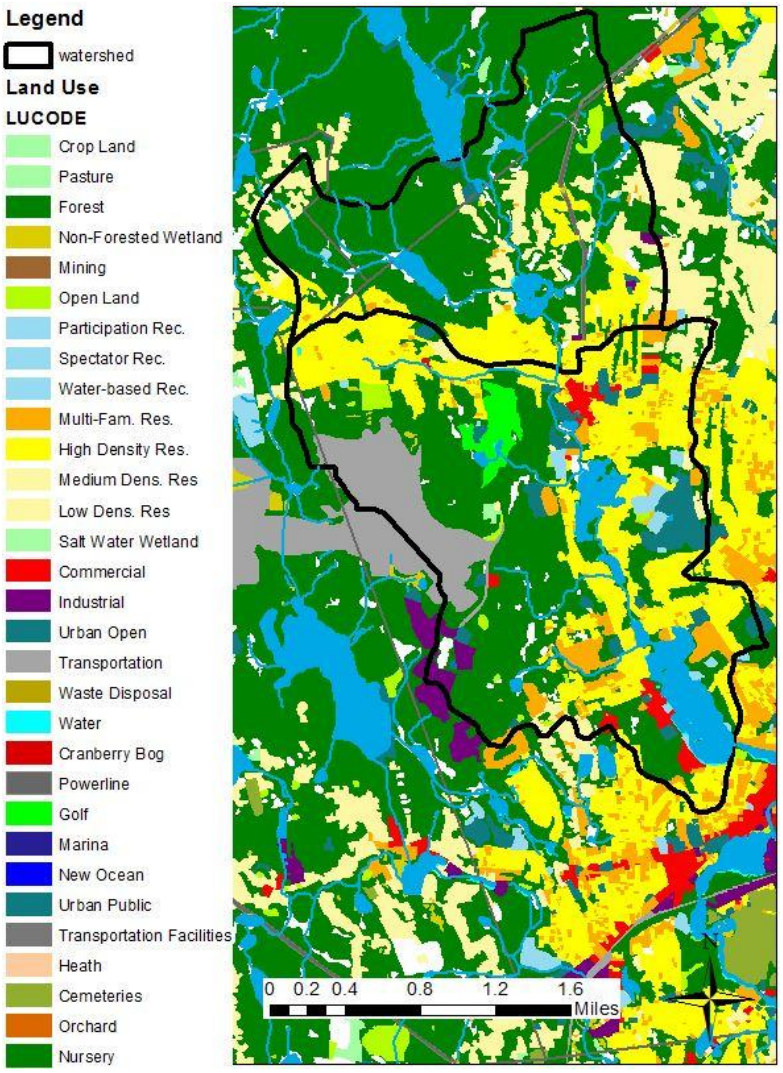


Figure 7 – Worcester, MA; Coes Pond Watershed Area Land Use Map 2005

4.5.2.2 Existing Land Management Practices

Land management practices are closely related to land uses. In fact, land management practices are created with respect to the land uses associated with a waterbody and the surrounding area. For the subcategory of existing land management practices, we found a table from the Patch and Coes Reservoir Management Study that displays potential management approaches for Coes Reservoir.

This table identifies potential targets for future management, and estimates costs of the management technique required to remedy the problem (Baystate Environmental Consultants, Inc., 2002). Although produced in 2002, we considered Table 17, below, to be useful because it provides a historical record of past management practices which can aid the design of future management practices.

Table 17 – Potential Management Approaches for Patch Pond and Coes Reservoir

Table 7. Potential Management Approaches for Patch Pond and Coes Reservoir*

Waterbody	Management Technique	Estimated Cost	
		Short-term	Long-term
Patch Pond	Dam study; reconstruction and stabilization	$150,000	
	Pond Drain Installation for annual drawdown	$50,000	
	Pond Dredging Program	$100,000	
	Install Sediment forebay at Mill St.	$100,000	$4000
	Herbicide treatment	$3,000	$2000
	Total Patch Pond	$400,000	$7000
Coes Reservoir	Pond Drain Installation for annual drawdown	$50,000	
	Pond Dredging Program for northern	$1,500,000	
	Install Sediment forebay at Mill St. and Williams Millpond	$125,000	$4000
	Repair stormwater outlet at Merriwether St.	$25,000	$2000
	Herbicide treatment	$10,000	$6000
	Alum treatment of southern portion	$100,000	
	Total Coes Reservoir	$1,760,000	$10,000

*Estimated costs are subject to further analysis. Permitting and design costs are excluded from the estimates and could add an additional 10-20% to the costs.

(Baystate Environmental Consultants, Inc., 2002)

MassGIS also provided a data layer on open space land management. This topic is concerned with managing land that is important to the area. For instance, areas of conservation are important when considering watershed management because conserving the land and habitat in the area leads to a healthier waterbody. We created the following to display the data layer.

4.5.2.3 Summary of Land Use & Population Characteristics Data

The data obtained in this section was valuable to our project because it provided a scope of the different land uses in the area. The table on terrestrial uses described in the land use and land cover category showed land uses such as: transport, residential, commercial, industrial, cropland, mining and so on.

MassGIS data provided us with the ability to create maps that display large amounts of collected data. For instance, the following map displays features in the Coes Pond region including: drainage culverts, land uses, streets, sewer lines, and soils.

All of the features shown on this map are important factors when considering a watershed management approach because they can contribute to current problems in any watershed. Ultimately, for the region around Coes Pond, the most detailed data layers of MassGIS were found under land uses. Many of the other data features on the above map were lacking in detail. For example, MassGIS had specific data on soils in some regions of Worcester, but not for the areas around Coes.

The fact that most of the MassGIS files we used are lacking in data is important because it limits the uses of the maps we created. The data files that do go into detail, such as the land use layers, can be used for watershed management purposes. However, the data files that do not go into detail, such as the Worcester soil layers, need to be updated because they provide no usable data.

Although some data in this section was outdated or lacking, it is important because land uses and land practices can impact a waterbody in different ways. Knowing how the land around the Coes Reservoir watershed is utilized, provides a better understanding of the waterbody itself, and the most likely causes of pollution. Overall, data in this section should be further developed in order to move forward with a WMP.

4.5.3 Waterbody & Watershed Conditions

The information provided in this section is a general overview of the health of the waterbodies in the Coes Reservoir watershed and the uses that are supported. The subcategories of the waterbody & watershed conditions section include: water quality standards, 305(b) report, 303(d) list, existing TMDL reports, and source water assessments. The following sections (4.5.3.1 – 4.5.3.2) describe the data we obtained for this section.

4.5.3.1 Water Quality Standards

Under this subcategory, we found a map from the EPA, Figure 8 – Waterbody Assessment and TMDL Status Worcester, MA in this report, which shows waterbody assessment and total maximum daily load (TMDL) status within Worcester MA, including Coes Reservoir. Coes is listed as 4c status meaning that no TMDL is required. (United States Environmental Protection

Agency, 2010). As explained in our background, a category 4c waterbody is one that is impaired but the impairment is not caused by a pollutant.

4.5.3.2 Summary of Waterbody & Watershed Conditions Data

Due to the impairment status of the Coes Reservoir watershed, most of the data necessities outlined by this section of creating a watershed management plan are not required. Because Coes is only a small part of a much larger watershed, and because a TMDL report is not required, it is not mentioned the 305(b) report or on the 303(d) list. This is good news because it means that less work is required in order to construct a watershed management plan.

4.5.4 Pollutant Sources

Pollutants can be delivered to waterbodies from various point and nonpoint sources. Identifying and characterizing sources are critical to the successful development and implementation of a watershed management plan and the control of pollutant loading to a stream. The subcategories concerning the pollutant sources section include: point sources and non-point sources. The following sections (4.5.4.1 – 4.5.4.3) describe the data we obtained for this data requirement.

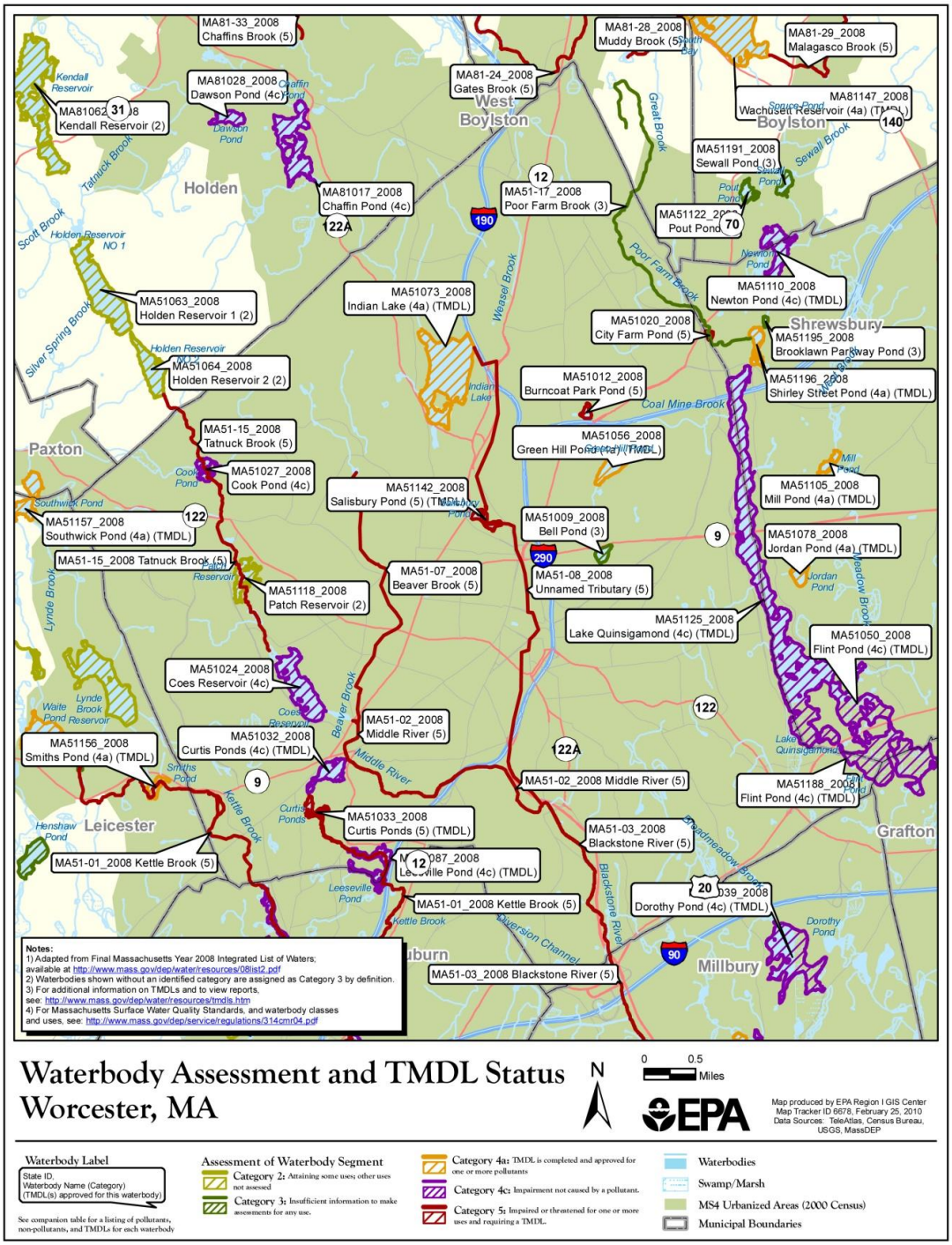


Figure 8 – Waterbody Assessment and TMDL Status Worcester, MA

(United States Environmental Protection Agency, 2010)

4.5.4.1 Point Sources

"The discharge of pollutants from point sources, such as pipes, outfalls, and conveyance channels is generally regulated through National Pollutant Discharge Elimination System (NPDES) permits" (United States Environmental Protection Agency Office of Water, 2008). This means that point sources are known, lawful sources of pollution that are monitored very closely. We were unable to find any point source pollution data on Coes Pond most likely because there are no wastewater treatment plants and no major industries in the area. Large industries and plants are the most common sources of point source pollution and are regulated by National Pollutant Discharge Elimination System permits (NPDES). NPDES permits are given to large industries that are discharging pollutants into waterbodies, these permits are only issued if the amount of pollution being discharged will not affect the water quality standards of the waterbody (EPA).

4.5.4.2 Non-point Sources

Nonpoint source pollution, unlike pollution from industrial facilities and treatment plants, typically comes from many diffuse sources (e.g. stormwater runoff), not specific pipes or conveyances. In a Worcester Airport Area Drainage Study performed in the year 2001, many non-point sources of pollution were identified that could cause problems for Coes Reservoir. This data not only identified the sources of pollution but also proposed potential solutions. Although useful, the data is outdated and should be used by future individuals, as a reference only. Many features in a waterbody can change over the course of fourteen years. The sites identified in this report should be checked again to see if restorations were made or if something is out of order.

4.5.4.3 Summary of Pollutant Sources Data

The data we found in the pollutant sources section was old and scarce. Point and non-point sources of pollution can cause impairments to a healthy waterbody. Future individuals who work on the health of Coes Reservoir should focus on providing more data on pollutant sources because Coes is a class 4c waterbody, which means that the waterbody lacks adequate flow and can become polluted if not maintained.

4.5.5 Waterbody Monitoring Data

A number of federal, state, local, and private entities monitor water bodies across the nation. Monitoring data, including chemical, physical, and biological data, are critical to characterizing a watershed. Without such data, it is difficult to evaluate the condition of the waterbodies in a watershed. The subcategories under waterbody monitoring data include: water quality and flow, biology, and geomorphology. The following sections (4.5.5.1 – 4.5.5.4) describe data we found in these subcategories.

4.5.5.1 Water Quality and Flow

Water quality and flow data is used to track the health of a waterbody. Different levels of health can determine what the waterbody can be used for. BEC Inc. (Baystate Environmental Consultants, Inc., 2002) provided an investigation on limnological data at Coes Reservoir. This investigation provides data on estimated nutrient loadings (such as: nitrogen, phosphorus, and suspended soils) in Coes Reservoir which can affect the habitat of the watershed. We excluded this information because this report was produced in 2002 which means the estimated loadings were outdated.

The EPA provided a table which shows the overall water quality assessment status of Coes Reservoir for the year 2012. Table 18 – Water Quality Assessment Status for Reporting Year 2012, below, describes water quality by displaying designated uses, designated use groups, and the assessment status of the specific uses. As seen below, fish consumption at Coes is impaired. This means that the water quality at Coes is not healthy enough to support the use of catch and consume fishing. Although this data is more relevant, some uses of Coes Reservoir have not been assessed. It is important that status of the reservoir be updated so that the public knows what they can and cannot use the waterbody for.

Table 18 – Water Quality Assessment Status for Reporting Year 2012

The overall status of this waterbody is Impaired.

Description of this table

Designated Use	Designated Use Group	Status
Aesthetic	Aesthetic Value	Good
Fish Consumption	Aquatic Life Harvesting	Not Assessed
Fish, Other Aquatic Life And Wildlife	Fish, Shellfish, And Wildlife Protection And Propagation	Impaired
Primary Contact Recreation	Recreation	Not Assessed
Secondary Contact Recreation	Recreation	Not Assessed

(United States Environmental Protection Agency, 2015)

4.5.5.2 Biology

Biological data is "essential for determining not only the biological health but also the overall health of a waterbody" (EPA handbook chapter 5, biology). The EPA provided a series of tables which display water quality assessment status of Coes, causes of impairment, and probable sources contributing to impairment for the year 2012. These data are shown below, represented by Table 19 – Causes of impairment for Reporting Year 2012Table 19, and Table 20.

Table 19 – Causes of impairment for Reporting Year 2012

Description of this table

Cause of Impairment	Cause of Impairment Group	Designated Use(s)	State TMDL Development Status
Eurasian Water Milfoil, Myriophyllum Spicatum	Nuisance Exotic Species	Fish, Other Aquatic Life And Wildlife	Non-pollutant impairment

(United States Environmental Protection Agency, 2015)

Table 20 – Probable Sources Contributing to Impairment for Reporting Year 2012

Description of this table

Probable Source	Probable Source Group	Cause(s) of Impairment
Introduction Of Non-Native Organisms (Accidental Or Intentional)	Other	Eurasian Water Milfoil, Myriophyllum Spicatum

(United States Environmental Protection Agency, 2015)

These tables show recent health problems of the Coes Reservoir and can also be used to categorize the watershed. This data is useful for estimating future problems and determining management practices to prevent these problems.

4.5.5.3 Geomorphology

Geomorphologic data analyzes the change in topography of an area over time due to human and natural causes. In our search, we found no geomorphological data. For the purpose of Coes Reservoir, this data is incredibly important because issues concerning sediment were brought up by the CZTF. Future individuals concerned with Coes should focus on obtaining geomorphological data to better understand factors that could be contributing to sediment issues at Coes Pond.

4.5.5.4 Summary of Waterbody Monitoring Data

In our research on waterbody monitoring data, we mostly found data concerning biology. The data included biological causes of impairment such as non-native plant species and also speculated that problems may be resulting from more invasive plant species. Obtaining more data for this section is incredibly important because Coes Pond has unevaluated issues that concern biology, water quality, and geomorphology. Future work should focus on producing or obtaining data for this section to improve the health of the waterbody.

4.5.6 Data Gaps

Our team located, organized, and analyzed data on a broad scale in order to provide the widest possible range of data that could be used for Coes Pond watershed management purposes. Although we found data for every category, there are certain sections which contain gaps and need further analysis.

We found the largest amount of data on the physical & natural features of Coes Reservoir. This was most likely because data on physical and natural features such as habitat, topography, and so on, are easily assessable topics that many organizations provide input on. However, much of the data we found for sections on pollutant sources, land uses, and waterbody monitoring data was outdated, missing, irrelevant or lacking. The most prominent sections lacking in data were the pollutant sources section, specifically non-point source pollution, and the hydrology section. Non-point source pollution is possibly the biggest threat to Coes due to its status as a 4c waterbody and more studies need to be conducted on this subject in order to ensure its future health. Hydrological data concerns the movement of water over land. We found very little data

on hydrology and more work needs to be done for this section because studying the water movement in the Coes Pond area can lead to a better understanding of the problems occurring today.

If more data is located to provide greater depth on Coes issues such as pollutant sources, land uses and waterbody monitoring, future steps can be made to create and implement a WMP. However, the current missing and lacking information represent "data gaps" that need to be addressed in order for a WMP to be developed. Although the data we have obtained over the course of this project is sufficient to achieve our goal of developing a framework for a watershed management plan for Coes Pond, there still exists the need to fill these data gaps to achieve the requirements defined by the EPA's *Handbook for Developing a Watershed Management Plan.* All of the data collected for this project along with any future data will still need to be organized in some sort of long term storage.

4.5.6.1 Required Data Storage Needs

The data storage requirements for a watershed management plan are a direct result of the type and projection of the data needed. With such a wide variety of collected information, it is necessary that the data be stored digitally to allow all stakeholders access to relevant data regarding the development of a watershed management plan. Examples of the types of stored data are: picture, document, and PDF files, containing maps and charts, as well as other digital files such GIS data layers. This creates a demand for a centralized location to store data large amounts of data as well as the capacity to store a diverse range of digital data types.

4.6 Data Storage Analysis

The main requirements for data storage for future projects or a watershed management plan include cost, amount of storage space, and accessibility. Cost was a major factor due to the nature of the stakeholders involved in Coes Pond. Another requirement for our data storage is due to an extent, by the nature of our project, collecting and analyzing quantities of data. By collecting and analyzing data for use in a watershed management plan, it became evident that this information would have to be organized and centralized.

Due to the full scope of this project and the relatively small amount of data needed to be stored, for examples PDF files or links to GIS datalayers, the most viable and useful long term data storage solution is cloud based storage, since open data repositories tend be more useful in situations involving much more data spanning more than one area. The stakeholders involved would benefit the most from using a product like Google Docs or Dropbox. Cloud based storage allows for a relatively inexpensive and easy to use interface. Stakeholders would also have full control over the moderating and maintenance, allowing them to expand or move data easily.

While most of the data we collected represents only a small portion of digital space, the GIS findings represent a smaller percentage of findings, but with a much larger percentage of storage space that it takes up, with possibly over two hundred data layers that are relevant to Coes Pond, it does not seem necessary to store the information in one spot. The recommended solution is one much like the one we followed in collecting and inventorying the GIS files. Linking the GIS data layers to the databases where they are located, via HTML link; offers another method of providing the relevant information while reducing the amount of storage space necessary to

contain all the collected data and information. The result is a smaller and more compact data requirement for the project. Ultimately the most viable solutions for the needs of this project can be broken down into two major types of online long term storage, cloud based service, and open access data repositories.

4.6.1 Cloud Based Storage

Cloud based storage was chosen because many companies offer products that range from free to use to relatively inexpensive. The cloud based storage options offer many advantageous possibilities. Products such as Dropbox and Google Docs offer free data storage, up to 15 GB, which can easily be accessed from a web browser. Cloud based storage is also a widely used method of data storage.

4.6.2 Open Access Data Repository

Another viable long term storage solution is the use of an open access data storage repository. Open access data storage repositories are typically used on the institutional level. They provide large scale storage and archiving solutions. Typically these programs are more expensive than the cloud based storage options.

Open access data storage repositories are very powerful and have the ability to handle, store and organize data efficiently. Services like Dspace allow administrators to create separate "communities", which typically represent departments or another broad category. Inside these communities are collections, which represent more detailed areas. Administrators are able to delegate responsibility and control over each collection to different people. Once a collection is

created, all registered users are able to submit content to the collection. When a registered user submits content, they are required to fill out a Meta data form, which provides a customizable form to be filled out that contains information about the content, like the author, title, or abstract. The user may then submit one or more files to the collection and agree to a disclaimer. This method forces the user, who submits to provide data on the file so it can easily be organized and found again. Also all submitted data must be reviewed by an administrator before appearing in the collection. Dspace is also search enable through all of its databases.

4.7 Recommendations for Data Storage

When accessing the data storage needs for this project many factors were considered. The options determined are the use of a separate self-operated repository like D-Space or Fedora, use of an existing repository, or a cloud based storage option like Dropbox. Some of these factors include: initial cost of the software and maintenance, accessibility, and security. Listed below are three of the most realistic and applicable long term storage options that best reflect our needs. The chart below shows a simple analysis based on the factors that each piece of software was assessed on. Each viable solution was simply graded and evaluated for the needs of the project, the results are contained within

Table 21 – Data Storage Qualities

	Annual Cost	Accessibility	Security	Data Storage
D-Space	$3750.00	Requires software to use	Secure offsite storage. Files are password protected.	75GB
Fedora	Free to use	Requires software to use	Secure offsite storage. Files are password protected.	Various
Dropbox	$99.00	Not required to use	Secure offsite storage. Files can be password protected.	Up to 1TB(1000 GB)

4.7.1 D-Space

Dspace is a piece of software that uses an open source platform for data storage and accessibility. Dspace main goal revolves around providing "open knowledge sharing and preservation". Users of Dspace are able to create and manage their own repositories. Dspace allows for many different digital storage formats.

Administrators in Dspace are able to create separate "communities", which typically represent departments or another broad category. Inside these communities are collections, which represent more detailed areas. Administrators are able to delegate responsibility and control over each collection to different people. Once a collection is created, all registered users are able to submit content to the collection. When a registered user submits content, they are required to fill out a Meta data form, which provides a customizable form to be filled out that contains information about the content, like the author, title, or abstract. The user may then submit one or

more files to the collection and agree to a disclaimer. This method forces the user, who submits to provide data on the file so it can easily be organized and found again. Also all submitted data must be reviewed by an administrator before appearing in the collection. Also on DSpace the contents of a collection, a collection, or a community can be searched from the main search bar.

4.7.2 Fedora ™

Fedora ™ is a free to use open access repository software. The Fedora ™ Repository software provides long term storage to digital resources to registered members. Fedora ™ is very useful in the fact that it can support all types of digital content. Fedora is often used as an electronic library and as an archive. In Fedora ™ a user, such as a business or organization, can create its own repository and have control over restricting certain items. It is worth noting Fedora ™ has an extensive list of copyright issues that restrict what can be uploaded to Fedora ™.

4.7.3 Dropbox™

Drop box is a widely used cloud based file storage system. The software is free with limited features and limit data storage of 2GB. Dropbox ™ premium and business class offer more functions, like password protecting individual files, and larger storage limits. Dropbox ™ is very user friendly and easy to use, as well as very widely used. Submissions are placed directly into a folder. Unlike Fedora ™ and Dspace Dropbox ™ doesn't typically use metadata, or communities to organize its files. Instead the moderators or other users can open added, move and organize data and files using various folders. Also labeling of content in drop box is not as efficient due to the lack of a proper metadata, but is still searchable using keywords.

5 Conclusion

Over the course of this project, our IQP team worked to produce a framework for a Coes Pond watershed management plan using the EPA handbook as a guide. The EPA watershed management plan handbook is a thirteen step process. Each chapter in the book covers a step of the process and completing any step of the process involves dedicated work. Our IQP team followed the steps based on chapters five, six, and seven of the EPA handbook focused on gathering existing data, creating inventories of the data, identifying data gaps, and analysis since they are the most important steps when creating a watershed management plan. Without obtaining data on a watershed, organizing that data so it can be easily found, and characterizing it based on importance, a watershed management plan would fail to produce desired results.

We identified stakeholders and categorized them based on their backgrounds. We collected and inventoried sources of data. We analyzed the sources to determine which sources would provide data relevant to issues on Coes Pond. We then analyzed the data from our sources and stated the characteristics of the data such as the type and usefulness. The framework produced by our IQP will aid future efforts to develop and implement a watershed management plan.

In addition, our IQP addressed the need for large amounts of data to be stored in a place where everyone interested has access. We addressed this issue by providing recommendations on data storage options. Ultimately this project was the first step of many in tackling issues concerning Coes Pond. However, this project will facilitate ongoing efforts to revitalize Coes.

5.1 Recommendations for Future Work

Two main issues still need to be addressed. The first is the scope required to develop a watershed management plan, and the second is the large lack of existing data and resources to create a watershed management plan. The scope of this project was not able to cover the full development of a watershed management plan, but rather to create a framework to assist and expedite the process of actually creating and implementing a watershed management plan. Based on our findings such as our workbooks, inventoried data, and GIS maps, our recommendations will focus on the completion of developing a watershed management plan.

5.1.1 Identify Data Gaps

In this project we only identified missing data. Although we identified general sections that were missing, it is important that all the necessary data is identified. Identifying data gaps is an important step because it is an evaluation that must be done in order to continue the process of developing a watershed management plan. The EPA describes three main types of data gaps; these are informational, temporal, and spatial data gaps. Informational data gaps include data that must be collected to accomplish stakeholder goals.

To accomplish this task, another student team could build on our work, or as one of our contacts suggested, a private contractor could be hired. There are many means to complete this recommendation; it depends largely on the resources and willingness of the stakeholders.

5.1.2 Collect Necessary Data

Another important step following the identification of missing data is to collect all the necessary data required to accomplish existing goals of the stakeholders. To do this it is important to understand the scope of obtaining the required information. Often times this requires field work and in situ testing. In this project a major obstacle our group encountered was a lack of existing data. Examples of possible data that would have to be collected include storm water runoff analysis, soil testing, additional water quality testing, or estimating pollution loads. These tasks are labor intensive and run the possibility of requiring a private contractor to complete.

5.1.3 Data storage

As described previously throughout Section 4.7, many possibilities exist that would satisfy the data storage requirements for a future project or the development for a watershed management plan. Using an analysis of existing software as well as considering the requirements, goals, and restraints of the stakeholders, we determined two viable recommendations. The viable options we determined were a self-operated cloud based storage system, or the use of an existing repository.

Due to the needs of the stakeholders and findings of this project it is recommended that the stakeholders utilize a cloud based data storage solution like Dropbox ™. Although open access repositories are very powerful and efficient it is not necessary for the needs of the stakeholders. Since open access repositories tend to be used on the university level, it is catered to handle large amounts of data for many different categories and subjects. Open access repositories are often implemented when multidisciplinary data sets need to stored, archived, and accessed. The option

of open access repositories just does not prove to be a viable and efficient solution. Cloud based data storage, although less powerful, offers a more cost effective solution for the needs and requirements of the stakeholders.

A possible alternative solution that could utilize an open access repository would be submitting the data to an existing repository. Since many universities use some form of online data repository, and are fully responsible for maintaining and protecting, it could prove advantageous to use another organization as a host. This would allow for all the benefits of using an online open access repository without all the costs and other efforts it would take to set up and moderate a new repository. This would be desirable because most of the costs and maintenance of the data would be avoided.

The second alternative option for using an existing repository would also be preferable if this project were to continue and expand to include other like projects. Using an existing repository would provide a framework on which to expand. While using an easier method like cloud based services, it has the possibility to no longer be adequate for the project. This would ultimately result in having to inevitably switch data storage options. Partnering with an organization that has access to a repository could be considered a proactive attempt, assuming the scope of this project will be expanded and will eventually demand a more powerful means of long term data storage. The means to accomplish this task are not covered in the scope of this project, but it is presented as an option. Ultimately, cloud based storage is the preferable and recommended means of long term data storage for the current project.

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Appendix – Water Resources IQP Workbook Excerpts

Sheet 1 Excerpt – Coes Zone Task Force Resources

Year	Type of Document	Title of Document (or subject if no title present)	Contents of Document/Description
2013	article/newsletter	Sustainable water management: Sanitary sewer overflows	This document contains general information regarding the topics of sustainable water management, and sanitary sewer overflows. It contains general information concerning water management, and causes and control methods for sewer overflows within the city of worcester
2013	Action plan progress report/ meeting minutes	Blackstone River (2004) 5 year action plan progress report	Lists objectives and commentions on the completion of certain tasks thus far
2013	Map	Worcester open space ownership map	Shows ownership of open spaces in Worcester by Parks, ConComm, God's Acre, Cemetaries, Mass Audobon Society, State Park, Worcester Public Schools, Hadwen Arboretum, National Grid, GWLT + GWLT Conservation Restriction, GWLT Easement, and Ponds and Streams
2012	Coes Pond improvement cost estimate	Coes Pond improvement cost estimate	Estimate for Phase 1 of improvements on Coes Pond from the Parks and Rec and cemetery division. Has individual estimates for the Coes Pond Mill Beach restoration project, the Coes Knife (Dam) project, Columbus Park project, and Knights of Columbus projects. Also lists the Grand cost total of all planned projects.
2012	Map + reports	Blackstone River watershed 2012 water quality monitoring sites	Includes a map showing all water quality monitoring sites in the Blackstone River Watershed in 2012. includes 76 subsequent volunteer water quality monitoring test results in the categories of aesthetics, temperature, dissolved oxygen, percent oxygen saturation, and nutrients ranging on a scale from not enough data to excellent. At the end of the document is a report card, summing up all of the collected results.
2012	2007 - 2012 testing results	Volunteer water quality monitoring program	Contains volunteer water quality monitoring results from 76 headwater tributaries, performed by the Blackstone River Coalition. Results span from 2007 to 2009 and judge qualities of water aesthetics, temperature, dissolved oxygen, % saturation, and nutrient level. Each waterbody, site location, and town is recorded for each of the tested waterways.

2012	Management plan update 2012	Comprehensive conservation and management plan update 2012	An update on the state of the program developed to improve the state of the Narragansett Bay watershed. This document contains information regarding the purpose and goals of the effort to improve the watershed, along with acknowledgements for the involved parties. The introduction to the program is followed by summaries/trends, management initiatives, and objectives/action tables for each of the following projects; Protect and restore clea water, Manage land for conservation and community, Protect and restore fish, wildlife and habitats, and Manage climate change impacts to natural systems.
2011	Application + maps	PARC grant + master plan for coes pond park facilities	The first portion of this document is an agenda from 8/3/11, on the topic of a PARC grant, and a Master Plan for Coes Pond park facilities. The second contains five maps of improvement sites on Coes Pond.The first map is of the whole Coes Pond, with important features of interest, such as beach locations, labeled. This map shows the public open space properties surrounding Coes Pond. The second map is of the Lower Coes pond area, labeling areas of intended improvements, as well as existing features. The third map highlights Columbus Park, labeling key features. The fourth map is of Coes Beach and Bathhouse property.The fifth map shows New city parcels in the Botany Bay area around Coes.
2010	Quality report	2010 Worcester water quality report	A water quality report for the city of Worster for the year 2010.Contains information regarding where Worcester's supply of water comes from, where the water is treated, water quality testing results with regards to chemicals, metals, and microbiological contaminants. Also contains information on the Cross Connection program, and results on the cross connection programs surveying efforts. Othere data such as temperature and pH levels were also recorded.
2008	Article	The Blackstone river: clean by 2015	An article describing the current and ongoing issues within the Blackstone Watershed. The project is outlined in the first chapter where goals such as reducing pollutants washed into the waterways and the volume of stormwater, and implement more stringent limits on nutrients such as nitrate and phosphate, are defined. Contents of the article include major issues facing the watershed, land use patterns, water quality and aquatic life in the watershed, flow in the blackstone river and its tributaries, recreation and river access, and tackling stormwater in the Blackstone River watershed.
2008	Newsletter	Lawn watering tips: green grass, not green ponds	Tips on maintaining your lawns and keeping ponds healthy
2006	Article	Coes Reservoir Dam rehabilitation project 2006	The article contains a brief background on the project, and the dam in particular. The reparation of the dam is briefly summarized as well, and then theres is a section on future visioning which is accompanied by a figure showing intended improvements, and outlining those improvements, to the lower Coes Pond area.

2006	Report	A brief account of the restoration of the Tatnuck Brook watershed	This report gives a historical account of the Tatnuck Brook watershed. Some of the contents include history of associations created to aid in the effort of keeping watersheds clean, an account of the Coes Knife project, and some history on the Coes Wrench Co. Efforts to improve the quality of Coes Pond are described as a historical account.
2004	5-year action plan	2004 Blackstone River watershed 5-year action plan	This report contains an overview of the Blackstone watershed 5-year action plan from 2004. Watershed background information is given, as well as history and an overview of the Blackstone River watershed. The report also contains water quality assessments from 1998, wet and dry conditions studies from 2000, project goals, and a feasibility study by Epsilon in 2003. Tests and studies are clearly outlined, and involved parties are mentioned along with timeframes. For all intended areas of improvement, objectives and action items are clearly outlined.
2002	Management Study	Patch Pond and Coes Reservoir Management Study	An evaluation of the limnology and lake management issue at Patch Pond and Coes Reservoir. The report focuses on the following goals: Survey of aquatic vegetation and sediment, waterbody morphometric and limnological data, secchi deep transmissivity, stormwater outlets, nutrient budget, and reccomendations for development waterbody management. The study took general measurements of the characteristics of Coes Pond, such as its size and flow. The report also contains land usage maps, as well as water quality testing results.
2001	Study/Brief Report	Airport area drainage study: Observations by location	This report contains observations made by Paul Bergquist on Thursday March 22nd of areas around the Worcester Airport. These reports were taken on a day with moderate rainfall inorder to asses the water flow in affected areas. All of the observations were made visually, in person, and address issues of poor stormwater runoff conditions.
2001	Report	Interim findings: Memorandum drainage study	This report offers an analysis of the poor drainage situations around the Worcester Airport. Because of the fact that many sub-watersheds are located in and around the airport area, this report was intended to impact the implementation of a watershed management plan, particularly concerning runoff and sediment pollution into watersheds in the area. Potential solutions are offered in addition to an outline of the surrounding area and problem area descriptions. Maps displaying the area surrounding the Airport are provided as supplemental material for the report.
2001	Report	"Supplemental Findings" Airport area drainage study	A summary of the findings from a study performed regarding the management of stormwater runoff in and around the Worcester Airport. This report gives detailed descriptions of all of the problem areas, offering suggestions as to which locations should be considered a high priority. This document intends to point out some of the areas containing major issued with stormwater runoff management.

2001	Report	Sedimentation and institutional partnerships in the Tatnick Brook watershed, central MA	This report contains an analysis of sedimentation in the Tatnuck Brook watershed. The report considers storm water drainage, erosion from construction sites into natural channels, private land use decisions, and historical morphological alterations. The effects of sedimentation on the Tatnuck Brook watershed are discussed, and reccomendations for the Tatnuck Brook Watershed Association to become more involved in the processes governing the changes to be made to the watershed are outlined. The causes, results, and remedies of sedimentation are explored relative to geographical conditions, storm water, private use, biodiversification, repair, and civil participation in the developmental process.
2000	Draft management plan	The Massachusetts non-point source management plan: Vol 1, strateigic summary	Volume 1 of the nonpoint source management plan brings together the action strategies of the management plan. The purpose of this document is to lay out a foundation for work that needs to be done in order to prevent, control, and reduce pollution from nonpoint sources to protect and improve the waters in Massachusetts.
2000	Memorandum	Summary on the status of the Coes knife project	Provides a segment on the history of the Coes Knife Company, and details regarding the three completed phases of the Coes Knife project; demolition, dam repairs, and Coes Park. The plan outlines projected necessary funds, and outlines the next steps that need to be taken in order to complete the project. Included, also, are maps detaiing the revised lot line of the city owned Coes Park parcel. The current budget status is also included at the end of the document.
2000	Maps	Blackstone River watershed	A map of the Blackstone River watershed in 2000. The watershed is overlayd over a map of the Blackstone area, showing city lines for all cities containing waterways within the Blackstone watershed.
1988	Topographic Map Topographic Map	Worcester South MA	Shows Map of Worcester which contains: contours, elevations (in meters), highways, roads, water features, woodland areas, geographic names
1988	Legal/financial plan to ensure future existence of Coes Pond	Coes Reservoir Study	Legal and financial solutions to stop the Dam from deteriorating
1990	Legislation enacted by city	City of Worcester Wetlands Protection Ordinance	Contains permits, definitions, security, enforcement, projects, regulations, and jurisdiction ideas with the purpose of protecting the wetlands in Worcester by controlling activities which have significant impact on wetland values. These values include: water supply, ground water, flood control, water pollution, fisheries, storm damage, and wildlife habitat.
1990	WPI IQP focused on eutrophication of Coes Reservoir and necessary repairs to the dam	Coes Reservoir Study (2)	Contents include: Brief history of Coes Reservoir, condition of the Coes dam and explanation of repair priorities, benefits of Coes Reservoir, losses involved with dam breach or failure, and Eutrophication problems at Coes Reservoir

1995	Report by the Worcester Department of Public Health and Code Enforcement on the Water Quality of Patch Reservoir	Patch Reservoir Water Quality Study (1994-1995)	Contents include: water quality testing methods and protocols, water quality test results, identification of pollution sources, point sources, municipal sewage, industrial discharges, non point sources, on site sanitary disposal systems, erosion and sedimentation, urban runoff, sampling data results, bacteriological data bar graphs, and septic system information
1996	Report on the Coes Reservoir Dam	Embankment Dam Study	This report contains a technical approach to the problem which analyzes costs and risks of the necessary dam repairs as well as environmental issues associated. The project experience, organization, and schedule are also included
1996	A Worcester Polytechnic Institute MQP	Feasibility Study of Water-Level Drawdown At Patch Reservoir, Worcester MA	This MQP contains information such as: lake management options, case studies of water-level drawdown, vegetation problems at Patch Reservoir, hydraulic analysis, and a preliminary design of the plan. This MQP also contains aquatic vegetation map of Patch Reservoir and a depth contour map of Patch Reservoir. The report is concerned with the lowering of the water level of Coes Pond, and tries to convince the reader that a drawdown would be both an efficient and positive method for ensuring that the water level in Coes Pond stays at a healthy level.
1997	Management Plan for Patch Reservoir	Patch Reservoir Management Program by GeoEnvironmental, Inc.	Contents include: hydrologic characterization of the watershed, land use assessment, point source storm water discharges, field reconnaissance of watershed, patch reservoir shoreline survey collection of limnologic data, survey of aquatic vegetation, sediment mapping and analysis, hydrologic budget and a phosphorus budget
2000	Report on Limnology	A Primer on Limnology	This report includes: physical, biological and chemical structure of lakes as well as lake classification and human influences. It also includes organizing a lake study. This document outlines what sorts of influences can have what kinds of effects on lakes, and how to maintain healthy conditions in a lake. The impacts of improper practices are explored in this document.
2000	Project prepared by the Executive Office of the City Manager	Coes Knife Project	The content of this project includes a history of the Coes Knife Company and the different phases for this project. Each phase includes its own description and costs. Phase I is demolition of the structures on the Coes Knife Property. Phase II is Coes Dam Repairs. Phase III is a description costs of Coes Park. The last section of this project is the Next Steps which discusses what comes after the repairs to the Dam.
2001	Study on Worcester Airport Drainage submitted by HNTB Corporation	Study on Worcester Airport Drainage submitted by HNTB Corporation	The contents of this study include an overview, general description of the project area, explanation of the drainage system, data collection, explanation of specific drainage problems and potential solutions, and cost estimates. This study also has a list of figures including: drainage study area figure and an existing watershed plan figure.

2001	Findings of the Worcester Airport Drainage Study	HNTB Airport Area Drainage Study Findings	These findings include observations and recommendations on different sections of the Worcester Airport as well as the surrounding areas being affected by the drainage problems at Worcester Airport. These findings also include potential improvement programs for 3-5 year scenarios. These improvement programs are made into tables which show the tasks and costs per year of improvement.
2001	Email with an attached draft of a volunteer water quality monitoring plan	Preliminary Water Quality Monitoring Plan	This draft focuses on turbidity, flow, and shoreline visual assessment. It describes each of these problems or variables and explains how the plan will address these problems. The draft also includes two tables, a soil alteration and vegetative stability index for stream banks, and a volunteer water quality monitor table. The water quality monitor table shows the location, variable being investigated, the volunteer and their contact information.
2002	Management study focused on an evaluation of the limnology and Lake management issues at Patch Pond and Coes Reservoir (Produced by Baystate Environmental Consultants Inc.)	Patch Pond And Coes Reservoir Management Study	Contents of this report are as follows. An introduction which provides the approach to the project. A description of the watershed including: general characteristics, vegetation, water quality, stormwater and drainage features of Coes Reservoir, and sediment analysis. This report also includes a hydrologic and nutrient budget. Lastly, the report contains recommended courses of action.
2005	Plan which focuses on improving Worcester's Open Spaces in order to make Worcester a city of ample recreational opportunities	City of Worcester Open Space and Recreation Plan	The contents of this plan include: an executive summary, conservation and recreation lands, community goals, analysis of needs, goals and objectives and a five year action plan . Another section is inventory and analysis. The inventory and analysis section includes data on geology, soils, topography, landscape character, water resources, vegetation, fisheries and wildlife, science resources and unique environments,

Sheet 4 Excerpt – Stakeholder Map

Organization Name	Contact Information	Description
North Attleboro High School Environmental Science	Donna Cochrane 508-643-2115 dcochrane@naschools.net	Students monitor Abbott Run for MA Class A Warm Water parameters of temperature, pH, DO, % DO, specific conductivity, N-NO3, soluble reactive phosphorus, fecal coliform, and macro-invertebrates.
First Herring Brook Watershed Initiative	Lance Van Lenten 781-545-5987 lnkrs@mediaone.net	Watershed Association based in Scituate, MA. Town Organizer for Biodiversity Days Recipient of DEP Source Water Protection Grant Plans to do watershed stream survey with guidance of the DFWLE Riverways Adopt a Stream Program and Monitoring Program Plans Public Outreach and Education Projects Sponsors Scout Projects
Tatnuck Brook Watershed Association	Lance Mckee 508-752-0108 lancemckee@charter.net	TBWA is the citizen organization that is the official Lakes & Ponds Adopt-A-Stream steward of Tatnuck Brook. Our purpose is to restore, preserve and maintain the environmental, water and recreational quality of the Tatnuck Brook watershed. TBWA meets three times a year and is responsbile for public awareness, resident,city & state governmental support towards these ends.
Leesville Pond Watershed And Neighborhood Association	Joan L. Crowell leesvillepond@earthlink.net	The Leesville Pond Watershed and Neighborhood Association is a grassroots organization of neighborhood residents whose mission is to work together with individuals, groups, businesses and agencies in order to improve and maintain the quality of life in the neighborhood.
Riverways Program, Mass. Division Of Ecological Restoration	Russ Cohen 617-626-1543 russ.cohen@state.ma.us	The mission of the Division of Ecological Restoration (DER) is to restore and protect the Commonwealth's rivers, wetlands and watersheds for the benefit of people and the environment. The Riverways Program (now a part of the DER) To promote the restoration and protection of the ecological integrity of the Commonwealth's watersheds: rivers, streams and adjacent lands. The Riverways Program was created to encourage and support local river protection initiatives as a vital complement to state action.

Trout Unlimited - Massachusetts-Rhode Island Council	Joesph Overlock 413-652-1638 joe.overlock@gmail.com	Massachusetts-Rhode Island Council of Trout Unlimited is the umbrella organization that all TU Chapters within the states of Rhode Island and Massachusetts. The Council is currently working to create a wild trout policy in Massachusetts. The Council also publishes "An Angler's Guide to Trout Fishing in Massachusetts" and works to help Chapters in educating anglers, habitat restoration and cold water conservation issues.
Kickemuit River Council	Ann Morrill 401-245-1095 Contact Email: annmorrill@verizon.net	Protecting the water quality of the Kickemuit River and its tributaries. Projects include both fresh and salt water testing, and monitoring water outflow discharge
Lake Singletary Watershed Association	Karen Norlin 508 865-2581 Contact Email: dnorlin@alum.wpi.edu	Lake Singletary Watershed Association is concerned about the impacts of rapid development on water quality of the Lake Singletary watershed, located in the towns of Sutton and Millbury. We plan to use our data to help local officials understand the issus so they can make informed decisions regarding future development
Blackstone River Watershed Council/Friends Of The Blackstone (Brwc/Fob)	John Marsland, President 401-644-3215 Contact Email: canoeman60@yahoo.com	Mission Statement: To restore, enhance, and preserve the physical, historical, and cultural integrity of the Blackstone River, its watershed and its eco-system, through public advocacy, education, recreation, stewardship and the promotion of this unique Blackstone Valley resource.
Strategic Cable Alliance	Michael Toomey 508-919-2092 Contact Email: Mike@SCTgrp.com	"WaterFronts" is show series designed to air via Strategic Cable Alliance. "WaterFronts" Series spotlights the relationship of waterbodies to communities, as well as cultural,economic social, educational, and recreationalimpacts. "WaterFronts"seeks out those groups and individuals that are making an impact in their watershed. And helps to empower the general public through suggesting ways they may be invited to participate.
Massachusetts Bays National Estuary Program	Jan Smith 617-626-1231 Contact Email: jan.smith@state.ma.us	The Massachusetts Bays Program (Mass Bays) is a partnership of citizens, communities, and government that strives to protect and enhance the coastal health and heritage of Massachusetts and Cape Cod Bays. To achieve our vision of a balanced and healthy environment, we: Provide support and assistance for local action Cultivate environmental education and stewardship Develop science-based initiatives to solve management problems
Community Pollution Prevention Project	Alison McDeedy Contact Email: Alison_McDeedy@nps.gov 401-762-0250	Interprets and protects the Blackstone Valley's environmental resources. Assists RI and MA state departments and local communities with technical assistance, land use planning, management coordination, and water quality issues.
Blackstone River Coaliton	Peter Coffin (508)753-6087 Contact Email: peter.coffin@zaptheblackstone.org	A network of citizen water quality monitors and test monthly 60 sites throughout the watershed. They seem to be a large network of groups, including some on this list.

Blackstone River Watershed Association	James Plasse (508) 839-2138 Contact Email: dwilliams@massaudubon.org	Miscoe Brook Stream Team is a quarterly monitoring project that assesses the water quality of the brook that feeds the lake where the town swimming area is located.
Smithfield High School	Holly A. Martin and Donna Williams 401 949-2050	An educational program at a local high school. The school seems to have students perform tests on the Blackstone and Woonasquatucket Rivers.
Regional Evironmental Council, INC.	Peggy Middaugh 508-799-9139 rec@ma.ultranet.com	A private, nonprofit organization formed in 1971 to protect and improve the central Massachusetts environment. Through research, educational programs, and citizen action, REC seeks to build public awareness and to promote the best possible choices concerning air and water quality, land use, waste reduction, recycling and transportation in our region. Focus on outreach & education to local residents through neighborhood groups. They seem to have connections with other organizations like Americorps, also they seem to have a large community involvement.
Citizens For A Clean Environment	Robert Craver (508)-943-277	C-FACE is a grass roots group of citizens joined together in the common goal of creating BMP's for a clean environment.
Blackstone River Watershed Education Project	Donna Williams 508-753-6087 Contact Email: bmbrook@massaudubon.org	Blackstone River Watershed Education Project is a high school water monitoring program. All 400 students conduct chemical, physical, and biological sampling three times per year. They gather in the spring at a local university for a Student Congress to share test results and strategize action plans.
Webster Lake Association	Richard Cazeault 508-949-0826 Contact Email: info@websterlakeassociation.org	Webster Lake Association is a non-profit organization dedicated to enhancing, preserving and protecting the quality of the lake and its watershed through the promotion of responsible, effective environmental & educational policies. We shall strive to strengthen and unite the Webster Lake Community through recreational, social and civic activities. Our mission is to preserve this regionally unique resource as a pristine legacy for future generations.
Quinebaug Rivers Association INC	Roger Hunt 508-755-4917	Quinebaug Rivers Association seeks to establish permanent riverine greenways along the Quinebaug River and its primary tributaries in Eastern Connecticut, South Central, Massachusetts, and Western Rhode Island.
Grafton Land Trust	Ken Crater Contact Email: ken@control.com	Private, nonprofit organization dedicated to the conservation of open space for the use of present and future generations of Grafton, Massachusetts and surrounding areas. We work in partnership with private landowners, town government, and other regional and national conservation organizations to conserve land through donation, purchase, or conservation restriction, and maintain hundreds of acres of land in Grafton for public enjoyment and conservation.

University of Rhode Island (URI) Watershed	Linda Green; Elizabeth herron 401-874-2905 Contact Email: URIWW@ETAL.URI.EDU	URI Watershed Watch is the largest water quality program in Rhode Island. Our goals include educating the public, promoting active citizenship participation, obtaining multi-year surface water quality data, and encouraging information-based water quality programs. With monitoring in all 14 of RI's watersheds, we cover cover the 'source to the sea.' Local sponsors pay an annual registration fee which helps cover the costs associated with training, equipment, laboratory analyses, interpretation and reporting of the data.
Knights of Columbus	John Reed Contact email: ReedJP123@yahoo.com	Active member in the Coes pond Task force
DEP	Therese Beaudoin Contact email: therese.beaudoin@state.ma.us	Department of Envionmental Protection offered Testing results from 2005
Lake Singletary Watershed Association	Richard Norlin Contact Email: dnorlin@alum.wpi.edu	Helped with the creation of the Lake Singletary Watershed management plan
DPH City of Worcester	Wayne Curran Contact Email: CurranW@worcesterma.gov	Chief Sanitarian for the city of Worcester DPH Beach testing and monitoring
DPW City of Worcester	Dave Harris Contact Email: HarrisD@worcesterma.gov	City of Worcester Department of Public Works. Gave MassGIS data to the team for further analysis

Authorship

Name	Chapters Contributions	Task Contributions
Alex Venditti	Abstract Executive Summary 2.5 Locating Watershed Data 2.8 Analyzing Data 3.1.2 Objective 2: Locating Data 3.1.4 Objective 4: Analyzing Data 4.2 Watershed Data Located for Coes Pond 4.5 Summary of Analyzed Resources 5 Conclusion	Inventorying Inventory Spreadsheet
Brian Flynn	Abstract Executive Summary 1 Introduction 2.1 A Brief History of Coes Pond 2.6 Inventorying Data 3.1.3 Objective 3: Inventorying Data 4.3 Inventoried data Authorship	Inventorying Inventory Spreadsheet GIS mapping Formatting/Editing of report
Edward Giles	2.2 Urban Watersheds 2.3 Watershed Management 2.7 Geographic Information Systems 2.9 Data Storage Needs and Solutions 3.1.5 Objective 5: Provide Recommendations for Data Storage 4.4 Inventoried GIS Data 4.6 Data Storage Analysis 4.7 Recommendations for Data Storage 5.1 Recommendations for Future Work 5.1.3 Data storage	Interviewing Interview Spreadsheet Interview Summaries GIS layer spreadsheet MassGIS layer research
Ryan Loucks	Acknowledgements 2.4 Stakeholders 3.1.1 Objective 1: Categorizing Stakeholder 4.1 Categorizing Stakeholders	Interviewing Interview Spreadsheet Interview Summaries