



# Massachusetts Coastal Water Treatment Facility Risk Assessment Tool

An Interactive Qualifying Project submitted to  
the Massachusetts Department of Environmental Protection  
and to the Faculty of  
WORCESTER POLYTECHNIC INSTITUTE  
in partial fulfillment of the requirements for the Degree of Bachelor of Science  
by:

Anthony Cangelo  
Nicolas Dupuis  
Asher Plange

---

Date Submitted:

October 12<sup>th</sup>, 2012

Project Advisors:

Susan Vernon-Gerstenfeld  
Angel Rivera

Project Sponsors:

Douglas Fine  
Ann Lowery  
Alan Slater  
Paul Niman  
Brian Brodeur

This report represents the work of three WPI undergraduate students submitted to the faculty as evidence of completion of a degree requirement. The views represented in this document are those of the authors and do not necessarily reflect the policies of the sponsoring organizations or its personnel. WPI routinely publishes these reports

## ABSTRACT

---

This project developed and implemented a climate adaptation tool that will assess the risk level of coastal water treatment facilities in Massachusetts due to the rising sea level. The sea-level is rising due to climate change caused by rising global temperature. The risk assessment tool utilizes several factors that would be detrimental to a coastal wastewater or drinking water treatment facility in the event of a flood due to sea-level rise. The risk assessment tool was applied to a random sample of facilities. The results were tested by packaging and presenting them to various audience members to gather feedback and reactions. This provided the group and sponsors at Mass DEP with recommendations for any potential follow-up work with the risk assessment tool in the future.

## EXECUTIVE SUMMARY

---

As the global temperature continues to rise, the world of coastal communities continues to face danger due to the rising sea level. By taking proper mitigating actions to accommodate the changing climate, wastewater and drinking water treatment facilities in coastal Massachusetts may reduce their risk of flooding. The development and implementation of the risk assessment tool was designed to assist the Massachusetts coastal treatment facilities in adapting to the effects of the changing climate.

In order to accurately develop the tool to quantify the risk of the coastal treatment facilities, some objectives had to be completed. First was the identification and addition to risk factors used in a preliminary study done by a group in 2011 (Blumenau, Brooks, Finn, Turner, 2011). The factors were developed and decided upon by our team in collaboration with the wastewater and drinking water specialists at Mass DEP. Once the risk assessment factors were finalized weights were produced in order to score them. The weights were also developed in collaboration with the wastewater and drinking water specialists at Mass DEP. In the following table, Table 1, the factors of the wastewater and drinking water risk assessment tools and their individual weights are listed.

Wastewater Risk Assessment Tool		Drinking Water Risk Assessment Tool	
Risk Factor	Weight	Risk Factor	Weight
FEMA Flood Zones*	16%	FEMA Flood Zones*	16%
ACE Hurricane Inundation Zones*	16%	ACE Hurricane Inundation Zones*	16%
Elevation of actual facility**	15%	Elevation of Facility	15%
Past Flooding*	8%	Surface or Ground Water (under/ not under influence) Sources**	10%
Design flow vs. actual flow**	8%	Treatment processes	10%
Precautionary Protective Structures**	7%	Past flooding*	8%
Surface/Ground discharge	7%	Precautionary Protective Structures**	7%
Longevity of backup power	5%	Onsite vs portable power	5%
Percent of processes that can run	5%	Longevity of power	5%
Rainfall induced flow*	5%	Percent of processes that can run	5%
Do you have equalization basins?	4%	Member of Mass WARN	2%
Member of Mass WARN	4%	Elevation of Storage Tanks**	1%

**Table 1.** Factors and corresponding weights for wastewater and drinking water treatment facilities

\* Factors used by the 2011 WPI group

\*\* Factors recommended by the 2011 WPI group

Once the development of the risk assessment tool was finished it could be applied to a random sample of coastal facilities in Massachusetts. First, the random sample of facilities had to be set up and identified. The selection for this sample began with lists of 134 coastal wastewater facilities and 146 coastal drinking water facilities. From there, a stratified random sample of 25 facilities from each list was produced. The finished risk assessment tools can be found in Appendix C, with the list of facilities on which the tool was applied.

The proper data for each factor was collected from each of the facilities in the sample to calculate the final risk value of each facility. There were three steps taken in order to receive this data. First, any information that could be obtained at Mass DEP through the DEP database was gathered. This consisted of three of the factors: surface/ ground discharge (wastewater), surface/ ground water sources (drinking water), and membership to Mass WARN. There was also an EPA study completed in the summer of 2011 that provided information on the backup power of some of the wastewater treatment facilities. Second, GIS maps were utilized to locate which facilities were in FEMA Flood Zones and/ or ACE Hurricane Inundation Zones. GIS was used to measure the elevation (above mean sea-level) of the facilities. Third, surveys were drafted and sent to each individual facility via email to acquire the remaining data necessary for the complete application of the tool. Each survey was followed up by a phone call to the facility. However, not all 50 of the facilities responded in time for us to apply the tool to all. There were 23 wastewater facilities and 14 drinking water facilities that responded, providing us with enough information to successfully apply the risk assessment tool to them. The survey responses from the facilities that did respond within the data collection period are in Appendix B. The final risk assessment tools with the information from each facility can be found in Appendix C.

Once the tool was successfully applied to the sample of coastal wastewater and drinking water facilities, the results were packaged in presentable forms. The risk assessment results for each individual facility were sent to the facility managers in the form of a two-page result sheet. These result sheets were created for each facility so that their results could be seen in several visual forms as well as personalized recommendations for their individual scores. The individual result sheets for each of the 37 facilities that participated in the application process can be seen in Appendix D. A five-page summary sheet was created that explains in detail how each of the factors for the tool were calculated and shows the results of each facility and can be found in Appendix E.

## ACKNOWLEDGEMENTS

---

We would like to thank the following individuals for their contributions to our project. Without their assistance, the project would not have been completed to its fullest possible extent.

Professor Susan Vernon-Gernstenfeld

Professor Angel Rivera

For their guidance and encouragement throughout the project

Professor Ingrid Shockey

For her knowledge and guidance in preparing the proposal and background for the project

Ann Lowery

Douglas Fine

Alan Slater

Paul Niman

Brian Brodeur

Sandra Rabb

Damon Guterman

For their assistance and guidance in making the development and application processes of the project systematic and successful

## AUTHORSHIP PAGE

---

Front cover page – *Anthony*

Abstract – *Anthony*

Executive Summary – *Anthony, Nicolas*

Table of Contents – *Anthony*

Acknowledgements – *Anthony*

List of Figures – *Anthony*

List of Terms – *Anthony*

Introduction – *Anthony, Asher, Nicolas*

Introduction Edits – *Anthony, Asher, Nicolas*

Literature Review – *Anthony, Asher, Nicolas*

Literature Review Edits – *Asher, Nicolas*

Methodology – *Anthony, Asher, Nicolas*

Methodology Edits – *Anthony, Asher,  
Nicolas*

Data and Discussion – *Anthony, Asher,  
Nicolas*

Data and Discussion Edits – *Asher, Nicolas*

Conclusion and Recommendations –  
*Anthony, Asher, Nicolas*

Conclusion and Recommendations Edits –  
*Anthony, Asher, Nicolas*

Appendix A – *Anthony*

Appendix B – *Anthony*

Appendix C – *Anthony*

Appendix D – *Nicolas, Anthony, Asher*

Appendix E – *Anthony, Asher*

Bibliography – *Anthony, Asher, Nicolas*

## TABLE OF CONTENTS

---

ABSTRACT.....	i
EXECUTIVE SUMMARY .....	ii
ACKNOWLEDGEMENTS .....	iv
AUTHORSHIP PAGE.....	v
TABLE OF CONTENTS.....	vi
TABLE OF FIGURES .....	x
LIST OF TABLES .....	xi
LIST OF TERMS.....	xii
CHAPTER ONE: INTRODUCTION.....	1
CHAPTER TWO: LITERATURE REVIEW .....	4
Climate Change and Sea-Level Rise.....	4
Water Treatment Facilities.....	7
Wastewater Treatment .....	7
Drinking Water Treatment.....	9
Coastal Management in Times of Climate Change .....	9
Case Study: The Coast of California .....	9
Case Study: The Coast of Brazil.....	12
Case Study: The Coast of Western Australia.....	13
Case Study: New York and Connecticut Coastal Resilience Tool .....	14
Summary .....	15
CHAPTER THREE: METHODOLOGY .....	16
Develop the Coastal Risk Assessment Tool .....	16
Identifying Additional Risk Factors.....	17

Final Wastewater Risk Factors: .....	18
Drinking Water Risk Factors: .....	18
Interviews.....	19
Develop Weights for the Risk Factors .....	19
Scoring Method for Risk Factors .....	20
Wastewater.....	20
Drinking Water .....	23
Application of the Tool.....	25
Identifying Which Coastal Facilities to Assess .....	25
Data Collection .....	27
CHAPTER FOUR: DATA COLLECTION AND DISCUSSION .....	28
Mass DEP Database.....	28
EPA Analysis .....	29
GIS Application .....	30
Surveys of the Facilities.....	32
Risk Assessment Results.....	35
Discussion.....	37
CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS .....	41
Conclusion .....	41
Recommendations.....	41
Recommendations for Mass DEP .....	42
Recommendations to the Facilities .....	43
Summary.....	44
BIBLIOGRAPHY.....	45
APPENDIX A: FACILITY VISITS .....	48



APPENDIX B: SURVEYS TO THE FACILITIES .....	51
Wastewater Facility Surveys.....	52
Barnstable (with EPA) .....	52
Chatham (with EPA).....	54
Dartmouth (with EPA).....	56
MWRA – Deer Island (with EPA).....	58
Hull (with EPA) .....	60
Lynn (with EPA).....	62
Manchester (with EPA).....	64
New Bedford (with EPA).....	66
Oak Bluffs (with EPA).....	68
Plymouth (with EPA).....	70
Salisbury (with EPA) .....	72
Scituate (with EPA) .....	74
Falmouth .....	76
Kingston.....	78
Moles Environmental Services, Inc. ....	80
Nantucket (Surfside).....	82
Automatic Coin Laundry .....	84
Black Rock Golf Community .....	86
Linden Ponds at Hingham.....	88
Pilgrim Power Station.....	90
Plymouth South High School.....	92
Spyglass Landing .....	94
White Cliffs Condo.....	96

Drinking Water Facility Surveys .....	98
Cambridge Water Department .....	98
Dartmouth Water Division.....	100
Edgartown Water Department .....	102
Mashpee Water District .....	104
Newburyport Water Department.....	106
Norwell Water Department.....	108
Pleasant Water .....	110
Rockport Water Department .....	112
Westport Senior Village.....	114
Pinewoods Camp, Inc. ....	116
Seatoller .....	118
The Baird Center.....	120
New Testament Church.....	122
Plymouth South High School.....	124
APPENDIX C: RISK ASSESSMENT TOOL.....	126
APPENDIX D: INDIVIDUAL FACILITY RESULT SHEET .....	128
APPENDIX E: RISK ASSESSMENT TOOL SUMMARY SHEET.....	204

## TABLE OF FIGURES

---

<b>Figure 1.</b> (a) Bar graph of GHG emissions every decade from 1970 to 2004, (b) Pie chart of different GHG emission concentrations in 2004, (c) Pie chart of causes of GHG emissions in 2004. (Bernstein et al., 2007 p. 36).....	5
<b>Figure 2.</b> (a) Changes in global average surface temperature, (b) Changes in global average sea level, (c) Changes in Northern Hemisphere snow cover from March to April ("Climate change 2007," 2007, p.31).....	6
<b>Figure 3.</b> Sea-level rise expected scenarios to the year 2100 (Heberger et al., 2009 p. 8) .....	10
<b>Figure 4.</b> Wastewater treatment facilities on California coast vulnerable to a 100 year flood with 1.4 m sea-level rise and their average discharge (Heberger et al., 2009, pp. 41) .....	11
<b>Figure 5.</b> Legend from EPA Analysis Map (EPA, 2011).....	30
<b>Figure 6.</b> (a) Cambridge Water Purification Plant shown in a 500-year FEMA Flood Zone (b) Cambridge Water Department shown in a Category 1 ACE Hurricane Inundation Zone (FEMA, 2012; ACE, 2009) .....	31

## LIST OF TABLES

---

<b>Table 1.</b> <i>Factors and corresponding weights for wastewater and drinking water treatment facilities</i> .....	ii
<b>Table 2.</b> <i>The water sources of the Cambridge Water Department.(United States Environmental Protection Agency [EPA], 2012)</i> .....	29
<b>Table 3.</b> <i>Wastewater survey question with the responses from the Scituate wastewater facility.</i>	33
<b>Table 4.</b> <i>Drinking Water survey questions with the responses from Cambridge Water Department</i> .....	34
<b>Table 5.</b> <i>Final risk scores for municipal wastewater facilities</i> .....	35
<b>Table 6.</b> <i>Final risk scores for privately owned wastewater facilities in South East Massachusetts</i> .....	36
<b>Table 7.</b> <i>Final risk scores for community PWS</i> .....	36
<b>Table 8.</b> <i>Final risk scores for transient non-community PWS</i> .....	36
<b>Table 9.</b> <i>Final risk scores for non-transient non-community PWS</i> .....	36

## LIST OF TERMS

---

ACE - Army Core of Engineers

BOD - Biochemical Oxygen Demand

CH<sub>4</sub> - Methane

CO<sub>2</sub> - Carbon Dioxide

DEP - Department of Environmental Protection

DWTP – Drinking Water Treatment Plant

EPA - Environmental Protection Agency

FEMA - Federal Emergency Management Agency

GHG - Greenhouse Gases

GIS - Geographic Information System

IQP - Interactive Qualifying Project

Mass WARN – Massachusetts Water/ Wastewater Agency Response Network

MGD – Millions of Gallons per Day

NAR - Northern Agricultural Region

ppb - parts per billion

ppm - parts per million

PROSAM - Environmental Sanitation Program of Metropolitan Region of Curitiba

PWS - Public Water System

RMC - Metropolitan Area of Curitiba

SRES - Special Report of Emissions Scenarios

WWTP - Wastewater Treatment Plant

## CHAPTER ONE: INTRODUCTION

---

As sea levels have risen due to climate change, impacts on the quality of drinking water and on hazardous wastewater management have increased. Previously, sea levels rose at an average of three millimeters every year (Bernstein et al., 2007). This may not have seemed significant at the present time, but the long-term effects of this increase were perceived to have consequences for coastal communities. A few major concerns that resulted from the sea level rise include more frequent flooding, intensified hurricanes, increasing salinity levels in groundwater aquifers and increased storm surges. These potential threats could have drastic effects on the population at large through the direct impacts on the functionality of coastal wastewater and drinking water facilities.

The purpose of water treatment facilities is not only to provide treatment and disposal of hazardous wastewater, but also to deliver clean and healthy drinking water to the community. Climate change and the rising sea-levels also pose a threat to the coastal environment and the everyday functioning of local communities.

As a result of sea-level rise, flooding in a treatment facility could contaminate the equipment and lead to a shut-down of the facility. In turn, this would prove to have significant implications on coastal communities. The implications may range from a minor inconvenience, such as consumers having to boil their own water; to major inconveniences such as a backup of wastewater, leading to a build-up of toxic materials. Flooding could also lead to increased salinity levels in the water supplies, causing a disruption in the chemical balance of the drinking water treatment processes. Coastal floods can cause irregular salinity level in the drinking water reservoirs, resulting in undrinkable water. Consequently, the increase in storm surges and hurricanes due to escalating global temperatures could have destructive impacts on the facilities.

The state organization that enforces these water quality standards is the Massachusetts Department of Environmental Protection. The Mass DEP is the state agency that is responsible for ensuring that air and water in the state are clean, as well as the safe management of toxics and hazards. Along with these responsibilities, the Mass DEP is also accountable for the recycling of solid and hazardous wastes, the cleanup of hazardous waste or spills, and the preservation of wetlands and coastal resources.

The Drinking Water Program that Mass DEP has implemented ensures that clean drinking water is delivered by the public water systems in Massachusetts according to the state and national standards. As climate change becomes more of a worldwide issue, agencies such as Mass DEP are facing new challenges to enhance protective measures for water treatment facilities.

The goal of our project was to develop a tool that would assess specific risk and impact factors facing water treatment facilities that were regulated by the Mass DEP. Our objectives for the project were as follows:

1. To identify the risk factors used in an earlier preliminary study (Blumenau et al., 2011).
2. To identify additional risk factors to water treatment facilities.
3. To produce weights for each factor based on their importance.
4. To identify the facilities for which we will be applying the tool.
5. To gather the data from the application of the tool at the facilities in order to present to stakeholders with a final risk assessment of the selected facilities.

We confirmed that the latest data was being used for the tool to ensure accuracy in the case that facilities had taken proactive measures since 2011. The following factors were contributed to this project from the first objective above:

- Elevation of facilities
- FEMA Flood Zones
- ACE Hurricane Zones
- Past flooding
- The flow rate ratio of the water through the facility

In addition to these factors, we included a wider range of criteria for the development of the tool. These additional factors include:

- Types of backup power, whether portable or onsite
- The potential to acquire aid in the event of an emergency via Mass WARN
- Presence of equalization basins\*\*
- Surface vs. ground water sources\*
- Analysis of treatment processes\*
- Presence of rainfall induced flow\*\*

Geographical Information Systems (GIS) could be used to map and predict future inundation and storm areas based on evaluations of climate change in the area. One key aspect to the development of the tool was the weighting of the factors by their significance to a facility at risk from the rising sea-level. The social implications of a flooded facility could be devastating, especially to the coastal community. We then evaluated how a shutdown of a water treatment facility will affect people in a coastal community.

To accomplish our goals and objectives we collected data using Mass DEP's database, GIS software, interviews and surveys we received from plant managers. Through these forms of data collection, received all the information we need pertaining to the development of risk factors, development of weights, scoring criteria, and specifications of selected facilities in order to produce a number value, corresponding to their level of risk.

The development and implementation of this tool gave the coastal facilities a means to make the necessary changes to adapt to the changing climate. The packaging of our findings as a tool would then be used by the coastal facilities to present to stakeholders and members of governing agencies. The results and findings that we package could effectively encourage stakeholders to motivate management for change, or steps for mitigating risks. The management may then provide funding for the necessary precautionary measures that need to be taken as a result of their risk level, determined by this tool, in order to minimize the above risk.

---

\* Factors only applied to Drinking Water Treatment Facilities

\*\* Factors only applied to Wastewater Treatment Facilities



## CHAPTER TWO: LITERATURE REVIEW

---

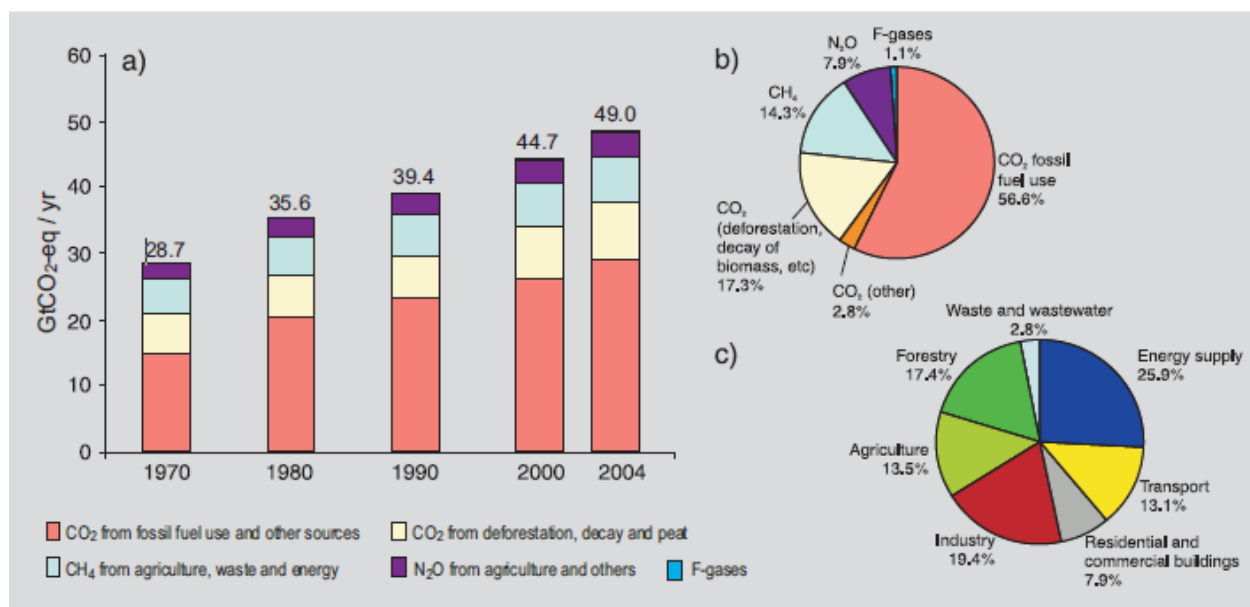
In the following chapter we present the background research for our project. We start with a description of climate change and how it is affecting the sea levels. From there, we describe the wastewater and drinking water treatment systems that are utilized by the coastal facilities. As a final point, we discuss research studies, which have analyzed the effects of climate change on coastal communities, featuring California, Western Australia, Brazil, and New York and Connecticut.

### Climate Change and Sea-Level Rise

A common misconception for the general public is the relationship between global temperature rise and climate change. They are often observed to be interchangeable terms; however climate change is a result of global temperature rise. Global temperature rise refers to the increasing of temperatures at a global level, while climate change is the change of national, regional and local weather patterns around the globe. Climate change affects rainfall patterns, storms and droughts, growing seasons, humidity and sea level ("What is climate", 2011).

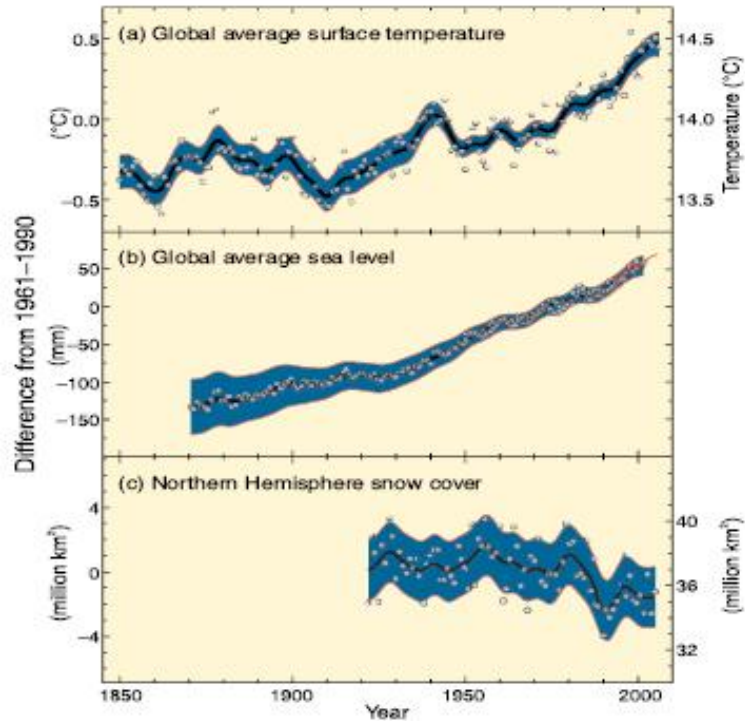
An increase in greenhouse gases (GHGs), including methane, nitrous oxide, carbon dioxide and halocarbons, has caused global temperature to rise ("Greenhouse Gases", 2012). The human production of these gases is faster than the atmospheric removal process, causing a build-up in the atmosphere. From 1970 to 2004, GHG emissions have shown to have grown by about 70% due to the increase of human industrial practices (See Figure 1, below). In 2005, the levels of carbon dioxide were 379 ppm, exceeding their natural range of 180 to 300 ppm. In 2005 the levels of methane were 1779 ppb, exceeding the natural range of 320 to 790 ppb. These levels are higher than at any point over the past 650,000 years ("Greenhouse Gases", 2012). This increase in these GHGs is mainly due to the use of fossil fuels (Bernstein et al., 2007).

### Global anthropogenic GHG emissions



**Figure 1.** (a) Bar graph of GHG emissions every decade from 1970 to 2004, (b) Pie chart of different GHG emission concentrations in 2004, (c) Pie chart of causes of GHG emissions in 2004. (Bernstein et al., 2007 p. 36)

One of the most prominent observed impacts of climate change is the noticeable rise in the global average sea level. Research has shown that for the past two decades, the average global sea level has risen at a rate of 0.6 mm to 1.0 mm each year. (Abel, 2012). Figure 2 shows trends over the past forty years. From this datum, it is evident that flooding is a major concern for coastal communities.



**Figure 2.** (a) Changes in global average surface temperature, (b) Changes in global average sea level, (c) Changes in Northern Hemisphere snow cover from March to April (*"Climate change 2007,"* 2007, p.31)

Government officials will often look at FEMA 100-year flood zone maps to see what land areas would flood during a 100-year flood. The terminology 100-year flood can be misleading; it does not mean that the area will flood only once every 100 years; rather it means that the area has a one-in-100 chance, or one percent chance, of flooding every year. Since the climate naturally varies, sometimes we observe multiple 100-year floods in short time periods. It is also possible for flood designations to change over time as more data is collected. When more data is collected scientists have the ability to change the 100-year flood maps to properly resemble the land that has a one percent chance of flooding every year (Dinicola, 2009). For instance, much of metropolitan New York is currently less than five meters above sea level. If a 100-year flood were to occur, 260 kilometers of the metropolitan area would be at an extreme risk for flooding. Furthermore, if a Category three hurricane were to hit New York City, these authors estimate that thirty percent of the south side of Manhattan would be flooded causing a disastrous loss of life and property (Colle et al., 2008).

In addition to these consequences that directly affect the citizens of a coastal community; ecosystems may also suffer because of the increase salinity level that occurs due to flooding. The heightened levels of salt in the water become detrimental to ecosystems as flora and fauna rely

on fresh water that would be contaminated. The shock to those ecosystems may result in a decreased supply of food and nutrients, damaged shelters, and ultimately the extinction of rare species native to the region. For example, if a freshwater source was to become contaminated with saltwater, this would pose a threat to freshwater fish due to their inability to adapt to this rapid environmental change (Carpenter, 1992).

## **Water Treatment Facilities**

The threat that flooding presents to the human and environmental systems at large has caused water treatment facilities to analyze risk factors to their utility components and methods of water treatment. Many cities along coastal regions are also primary locations for the regional wastewater and drinking water facilities. Due to the ease of accessibility to a large water source many agencies develop and build their facilities in these coastal areas. The importance of the functioning of the water treatment facilities in adverse in adverse conditions is clear; without fresh drinking water or the quick removal and sanitation of waste-water communities would suffer from contamination and pollution. (Whittaker, 2007). Here we describe in greater detail the systems that characterize most water treatment facilities.

### **Wastewater Treatment**

The process by which wastewater is treated is lengthy and complicated. These facilities utilize a three-step process to clean the water. This three-step process consists of primary, secondary and advanced treatment to properly manage and dispose of harmful substances in the wastewater.

Primary treatment involves the pre-treatment of the wastewater, which removes pollutants and particles that may harm the machines in the facility. These pre-treatment processes include components such as the bar rack, grit chamber and the equalization basin (Davis, 2009). Bar racks are the first component that wastewater encounters when it enters the facility, the purpose of the bar rack is to remove large objects that would damage the more sensitive machinery in further processes. This could include logs, solid trash and other objects that would damage the equipment. The openings in the bar racks are typically 40mm to 150 mm wide to stop these large objects from entering the facilities. After the bar racks, grit chambers are in place in order to prevent more fine solids from passing through to the other machinery. Such materials consist of sand, broken glass and silt. If these materials were not removed they would wear down

the machinery and settle in corners, reducing the flow rate (Davis, 2009). The final primary process is the equalization basin, also referred to as flow equalization. The purpose of flow equalization is to provide the facilities with a constant flow rate of wastewater. The basins store all incoming wastewater, from which it is pumped at a constant rate into the facility. The equalization basin dampens the variations of the incoming flow rate to match the flow rate of the facility. After primary treatment, the wastewater is then introduced into the secondary treatment.

In addition to the steps executed in the primary treatment, the secondary treatment includes using the primary settling tanks. Biological processes are utilized in the secondary treatment to remove any soluble particles that may have escaped the primary treatment. These tanks utilize such systems as fixed-film and suspended-growth in order to remove hazardous biological contents from the water (Whittaker, 2007).

Finally, if necessary, the advanced treatment stage uses final processes such as chemical treatment and filtration to remove such elements as carbon and phosphorus to make the water usable. Although secondary treatment and disinfection can remove over 85% of Biochemical Oxygen Demand (BOD) suspended solids and nearly all pathogens it only removes some pollutants. Pollutants not removed by secondary treatment and disinfection may be a major concern at high levels but can be removed through advanced water treatments. These stages of advanced water treatment are filtration, carbon, absorption, phosphorus removal, nitrogen control, nitrification-denitrification, and ammonia stripping. Filtration removes left-over suspended solids and micro-organisms that were not removed in the previous steps. Typical sand filters clog too quickly and need to be changed often. To solve this issue, three filter grain sizes are used. This allows fewer filter changes and creates for a more efficient system by removing 70% to 80% of solids. After all these processes, refractory compounds remain and are absorbed through activated carbon. Phosphorus is removed to prevent eutrophication; this is done through chemical precipitation consisting of chloride, lime, or alum. The process requires a reaction basin or a settling tank. The final step of advanced water treatment is nitrogen control. Nitrogen is removed to control algal growth. This can be done either biologically, by nitrification-denitrification, or chemically, by ammonia stripping (Davis, 2009).

## Drinking Water Treatment

In order to provide communities with safe and reliable drinking water, certain treatment processes must be taken by public water systems (PWS) to ensure the standards. The main drinking water treatment processes consists mainly of these steps: coagulation, sedimentation, filtration, disinfection and storage. These treatment processes may vary based on certain factors like the use of ground water as opposed to surface water, the capacity of the system, as well as the prior quality of the source water.

Coagulation removes dirt and other particles by adding alum and other chemicals to the water. The alum and other chemicals attract the dirt and form small particles called ‘floc’. The dirt and chemicals combined are too heavy to float and sink to the bottom. During sedimentation this floc settles to the bottom, leaving the clear water to move on to the next stage of filtration. During filtration the water passes through filters made up of sand, gravel, or charcoal. The filtration step removes smaller particles that were too small for sedimentation. Before moving on to storage, the water is disinfected by adding a small amount of chlorine to kill any bacteria. The water is then placed in a tank or reservoir to be dispersed to households (EPA, 2004).

## Coastal Management in Times of Climate Change

We reviewed a variety of cases that dealt with responses to rising sea-levels due to climate change. We used the studies to increase our knowledge regarding the major issues for wastewater and drinking water facilities. The studies consist of analyses of the impacts of the rising sea level along the coastal regions of California, Western Australia, Brazil, and New York and Connecticut.

### Case Study: The Coast of California

In 2009 the California Climate change center conducted a study on the impacts of sea-level rise on the coast of California. As a result of this study, the mean sea-level is projected to rise from 1.0 to 1.4 meters over the next 100 years, approximately three times the average rise in global sea-level for the 20 years prior to this study (Heberger et al., 2009). Since the California coastline is already at risk for storms and high tides, this projected rise in the sea level will only leave it more vulnerable.

The challenge facing California, is that it was estimated by the Special Report on Emissions Scenarios (SRES) that there will be one of four resulting levels of future GHG emissions, creating four different projected climate change scenarios in a specific timeframe (Heberger et al., 2009). These scenarios for the effects on sea-level rise are shown in Figure 3 estimated to the year 2100.

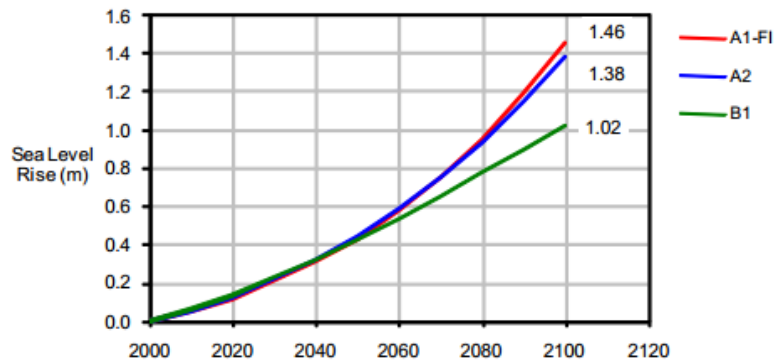


Figure 3. Sea-level rise expected scenarios to the year 2100 (Heberger et al., 2009 p. 8)

Based on these correlations and the analysis of GIS maps and other data, the expected coastal risks and regions threatened by this sea-level rise were determined by the California Climate Change Center (CCCC). This sea-level induced flooding threatens many resources. The populace will be disrupted in many ways, including forced evacuations, destruction of property, personal as well as provincial, and monetary costs. Important factors to take note of are also the inundation and erosion hazards in the area. Aside from the property and personal damage that ensues from flooding, numerous coastal facilities and infrastructures are at risk. These include schools, healthcare facilities, fire and police stations, airports, power plants, roads and bridges and wastewater treatment plants.

Wastewater treatment facility pumps and other equipment become damaged from the flooding, but interference with the discharge could cause result in hazardous waste spills due to the higher water levels (Heberger et al., 2009). These wastewater facilities were mapped across the California coast in Figure 4.

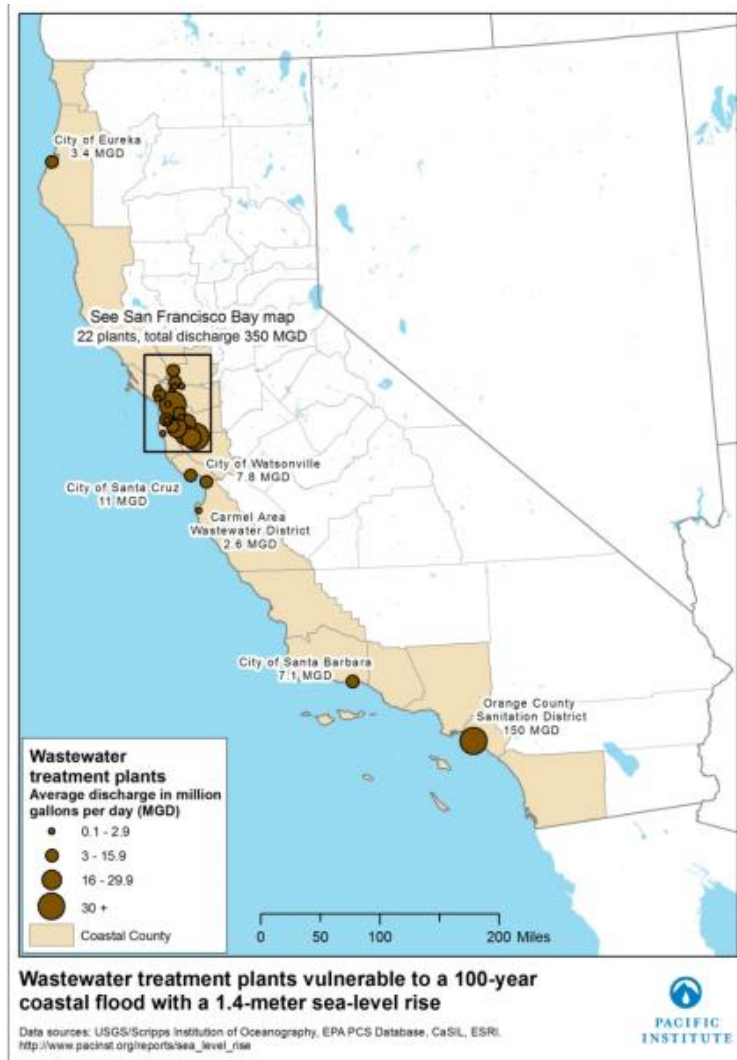


Figure 4. Wastewater treatment facilities on California coast vulnerable to a 100 year flood with 1.4 m sea-level rise and their average discharge (Heberger et al., 2009, pp. 41)

Based on these models, there is also a risk of intrusion on freshwater supply sources. As saltwater floods the coast, it also intrudes on groundwater resources which water treatment plants use as sources for drinking water as well as irrigation. This freshwater source is also used for communities drawing water from wells. Communities drawing water from wells would be forced into searching for alternative drinking water supplies as water insecurity increases. This is more costly and inconvenient for these communities. Several actions have been taken and are being developed to mitigate this saltwater intrusion, including limiting of impervious areas, conserving water to reduce pumping, and building infiltration basins to reduce the magnitude of saltwater intrusion (Heberger et al., 2009).



## Case Study: The Coast of Brazil

Cities located along coastal regions are prone to flooding. Regions where water facilities are located require space and protection from flooding. With the recent changes in the climate, flooding has become an increased concern among coastal facilities. Due to the potential damages and inconveniences that flooding brings, The Metropolitan Area of Curitiba (RMC) (State of Paraná, Brazil) has taken preventative measures as well as developed solutions for the two types of flooding they encounter. This case study addresses the Flood Management Plan that was implemented to prevent urbanization flooding and natural flooding of the flood plains, while mitigating the costs of the preventative measures that were taken.

Urbanization flooding usually occurs in the downtown area of Curitiba as well as in the intensely populated cities of the metropolitan area and has the potential to increase flooding. Although there have been regulations put in place to prevent citizens from settling on flood plains and areas where water basins are located, many citizens continue to settle in these areas. This proved to be disastrous in 1983 when a major flood hit, and the cost to compensate for the damages was a steep sum of 50 million US dollars (Tucci, 2004). The planners were able to develop a flood management plan perfectly tailored for this specific region after taking a closer look at the Iguacu River's small river conveyance, its bottom slope and also its low river capacity of 55 cubic meters per second.

The flood management plan that was devised was made of two parts. In an effort to provide safety to the citizens who have already inhabited the dangerous flood plain area, accommodations were made to prepare the region for 50 or 100-year flood waters (Tucci, 2004). By creating physical barriers such as river channels, roads, and railways the planners are essentially removing the availability of land from the equation. If there is no land to be occupied in close proximity to the water basins and facilities, then there will be no urban flooding.

As a solution to the natural flooding concerns, planners and engineers decided that creating a natural form of draining would be beneficial. By lengthening the river basin by at least 50 kilometers through drilling methods, flood waters would not be able to have the same catastrophic effects on flood plains. Though they may prove to be a costly procedure, the long term benefits may out-weigh the short-term costs; along with construction of dikes with internal drainage abilities to protect the facilities and basins that provide water to this specific Curitiba region, these arrangements prove to have the ability to mitigate costs if there were to be another

flood. This flood management plan is part of a larger “Sanitary Program” PROSAM that has been created to deal with the overall effects that the environment has on metropolitan area of Curitiba (RMC) (Tucci, 2004). PROSAM is a Spanish acronym meaning “Mines Environmental Sanitation Program” that is being developed to mitigate the negative effects of sea-level rise.

### **Case Study: The Coast of Western Australia**

In the beginning of 2011, the Australian government realized its need to focus on the sustainability of the western coast of Australia. Australia has over 80% of its citizens living within 50 kilometers of the coast and over 30% of its citizens living within two kilometers of the coast. Due to this, Australia’s population is very susceptible to global climate change and sea level rise. Not only that, but the average sea level rise along the west coast of Australia from 1991 to 2009 was 8.6 mm/yr., compared to just 3.0 mm/yr. for global sea level rise, meaning that the sea level along the west coast of Australia is rising nearly three times faster than the global sea level due to climate variability. The rise of sea-level is of particular concern for Australia since all of the country’s capital cities are located along the coast (Collins & Stevens, 2011).

Along the western coast of Australia, in an area known as the Northern Agricultural Region (NAR), there is a 500 km strip of coast in which there is poor public access to the coast. The lack of packed roads has resulted in people creating their own track of roads to access the coast using four wheel drive vehicles. Unfortunately, the tracks were created out of convenience rather than necessity. The large network of roads has begun to destroy both the vegetation and the land itself. The loss of this vegetation creates an even greater risk to both wind and water erosion. Australian officials have realized that with their eroding coast and quickly rising sea levels, they need to act in order to preserve their land from being destroyed.

The Department of Environment and Conservation (DEC) decided that a Geographic Information System (GIS) analysis would be used to assess and manage the coastal impacts as well as aid in future developments of the NAR. The DEC chose GIS because it allows them to document land information, can be updated in the future with new information, and has analysis capabilities. The authors, Alexandra Stevens and Lindsay Collin, also describe GIS as being a decision enabling tool (Collin & Stevens, 2011). The goals for the GIS system were to use it to plan on-ground developments, monitor environmental changes along the coast as well as to record the recovery of the trails over time, and to implement and test different strategies before

development. The developers decided that they should focus their attention first to high land use areas. This was described as a four hectare square area having more than 280 meters of track. A hectare square is 10,000 square meters.

The goal of the development of the GIS data set was to help rehabilitate the region. To accomplish this, researchers focused their attention first at the most affected regions. For instance, there is an area known as Wedge Island that only makes up 0.2% of the total project area yet contained two percent of the entire track network along 2.5 km of coast. In order to rehabilitate the NAR region of Australia some of the four wheel drive tracks were closed and the paved roads were planned and implemented. These paved roads will allow citizens and visitors a road to access the coast so that they do not need to create their own tracks and further destroy the land.

It is important to note the Brunn Rule in this case. The Brunn Rule states that along wave-dominated coasts, as opposed to tidal-dominated coasts, for every one centimeter in sea level rise there is 100 cm of coastal retreat. It is projected that over the next 100 years along the western coast of Australia there will be 110 cm in sea level rise. According to the Brunn Rule this will result in 110 m of coastal retreat (Collins & Stevens, 2011). This number will be even larger if the coastline continues to be destroyed by four wheel drive vehicles because less vegetation will make erosion more likely. The GIS system will be used to monitor access roads as well as plan future strategies for sea level rise. The GIS will give officials a tool that is able to be updated in the future as new information becomes available and quickly observe the potential effects of the new information.

### **Case Study: New York and Connecticut Coastal Resilience Tool**

The shores along Connecticut and Long Island are home to about 7.5 million people (“New York and Connecticut”, 2008). These shores are very low in elevation and are in turn very susceptible to flooding from the rising sea level. Though facing extreme risk due to climate change, these shores are some of the most highly developed coastlines in the world.

As time has passed, the realization has set in that traditional adaptation to these coastal risks such as engineering defensive structures and hardening of the shoreline can often be unsuccessful. However the implementation of ecosystem-based adaptation by the human community has yet to be thoroughly explored. The Coastal Resilience project for the New York

and Connecticut addresses areas of risk of these highly developed coastlines (“New York and Connecticut”, 2008).

Similar to the tool that we have developed, the Coastal Resilience tool is an interactive tool that explores future flooding scenarios by mapping and following the rising sea levels and storm surges for these coastal areas (“New York and Connecticut”, 2008). After the application of the tool to these highly populated areas, The Nature Conservancy made recommendations based on the severity of the effects of climate change in certain areas. This tool’s simplicity allows one to become quickly knowledgeable of the risks that these regions face, while broadening the window of communication between the community and various branches of planning bodies at regional and state levels.

This effect is similar to what we intend to accomplish with the development and implementation of our tool. Our risk assessment tool will not only quantify the risk that drinking water and wastewater treatment facilities face due to the rising sea level, but also it will provide facilities and the communities they serve with the information necessary to push for change. This will give governing bodies what they need to make informed decisions on how to adapt to the changing climate that all coastlines are facing.

## Summary

In summary, a review of the literature found that climate change tools were becoming increasingly vital to both water treatment plants as well as the people they serve. We learned that GIS has been and can be used to monitor areas of high concern based on geographical contributors and data. There was also an impact on the decisions being made to deal with the risks and potential impacts of the changing climate. The impacts may have lasting effects on industries, infrastructure and properties that exist in these areas at high risk for flooding and increasing storm surges.

## CHAPTER THREE: METHODOLOGY

---

The goal of this project was to develop a tool that will efficiently assess risk factors at coastal water treatment facilities that face the possibility of flooding due to the rising sea level. The findings were then presented in a clear and concise manner using graphs, charts and descriptions of the scoring methods. The goal was achieved through the following:

1. Develop the coastal risk assessment tool
2. Apply the tool to selected coastal water treatment utilities

In this chapter we summarize the methods that we utilized to complete our goals and objectives for the project.

### **Develop the Coastal Risk Assessment Tool**

Our first goal is develop a tool to assess the risk a coastal wastewater or drinking water treatment facility faces due to the rising sea level. The completion of the following objectives will allow us to achieve this goal:

- Identify the risk factors used in an earlier study by the 2011 WPI and Mass DEP team described in the introduction chapter (p. 2)
- Identify additional risk factors that affect water treatment facilities
- Produce weights for each factor based on importance

We began the project by identifying the risk factors utilized by the 2011 team. We conducted a revision of these factors in the development of the tool to ensure the accuracy of the data collected and re-evaluated the relevance of their chosen factors. Through an interview with the 2011 team we gained a better understanding of the risk factors they addressed and included in the development of their tool. Along with this interview, a conference call with Mass DEP provided us with specific information pertaining to various aspects of the coastal water facilities that prove to be relevant in the establishment of the risk factors for the tool. The conference call to Mass DEP included Ann Lowery, Deputy Assistant Commissioner, Douglas Fine, Assistant Commissioner, Alan Slater, Chief of the Wastewater Permitting Program, Paul Niman, Chief of the Drinking Water Permitting Program, and Brian Brodeur, GIS Program Director. The factors that we had revised and evaluated from both the 2011 WPI team and Mass DEP include:

- Past flooding of sectors of the facilities

- Located in Federal Emergency Management Agency (FEMA) Flood Zones and Army Corps of Engineers (ACE) Hurricane Inundation Zones
- Elevations of individual facility components
- Presence of precautionary protective structures
- Design flow vs. actual flow
- Population served
- Surface or Ground discharge
- Longevity of backup power
- Percent of processes that can run
- Interconnections of facilities
- Environmental impacts
- Rainfall induced flow
- Presence of Equalization Basins
- Membership of Mass WARN

### Identifying Additional Risk Factors

The factors to assess which facilities are at the highest risk were identified through our research of the following categories: the areas of facilities impacted during floods, significant precautionary measures that a facility should be equipped with in the event of a flood, and some of the major design specifications of the facilities, such as elevation. In collaboration with the team of Mass DEP representatives, we compiled a list of factors that were the most significant to a facility's capability to operate when flooded. Finally, to better develop the risk assessment, we took into account a facility's ability to avoid flooding by way of any physical barriers or other preventative measures taken.

Throughout the development process some of the factors that were initially considered, were not included in the tool. Many factors proved to be either too detailed, or did not directly contribute to a facility's ability to function during a flood. These factors included environmental impacts of flooding, a facility's interconnections and the number of people a facility serves. Creating a tool that was too specific would render the tool unusable for a large number of facilities, whereas a more general tool could be applied to a wide range of facilities. This would provide us with more data, resulting in a better survey and application sample. When

determining the importance of each risk factor, relative to the others, we met with the Chiefs of the Wastewater and Drinking Water Permitting Programs, Alan Slater and Paul Niman, separately to discuss the factors. The final list of Risk Factors for wastewater and drinking water facilities are listed in order of importance.

***Final Wastewater Risk Factors:***

- FEMA Flood Zone
- ACE Hurricane Inundation Zone
- Elevation of Facility (meters)
- Protective Structures
- Design Flow Rate
- Average Flow Rate
- Discharge (Surface, Ground)
- Longevity of Back Up Power
- Processes that Can Run
- Rainfall Induced Flow (MGD)
- Equalization Basins
- Members of Mass WARN
- Past Flooding

***Drinking Water Risk Factors:***

- FEMA Flood Zone
- ACE Hurricane Inundation Zone
- Elevation of Facility (meters)
- Past Flooding History
- Water Source (SW, GWUDI, GW)
- Treatment Processes
- Protective Structures
- Onsite Power
- Longevity of Backup Power
- Processes That Can Run
- Membership of Mass WARN

- Elevation of Storage Tanks (feet above mean sea level)

## Interviews

To aid us in identifying other significant factors we consulted with Professor L. Albano, a Civil and Environmental Engineering professor at WPI. On site we consulted with operators from the wastewater and drinking water treatment facilities. These interviews were set up one we were on site in order to provide us with more detailed background knowledge of treatment facilities. Their understanding of the structural and the operational workings of these facilities proved essential to the development of the tool. The information obtained was collected through interviews with human resources and plant managers of the facilities. Summaries of our site visits at Scituate and Hull WWTF and Worcester DWTF can be found in Appendix A.

Various meetings with Mass DEP's and drinking water specialists also provided us with a more specific understanding of the treatment processes each type of facility has. These specialists consisted of the Alan Slater, the Chief of the Wastewater Permitting Program and Paul Niman, the Chief of the Drinking Water Program. Overall, those interviews provided us expert opinions to help us correctly derive weights, according to the impact a given factor has on a facility, in the event of a flood.

## Develop Weights for the Risk Factors

Once we determined which risk factors would be included in the tool, we assigned weights to each factor based on importance and potential detrimental impact it may have on a facility in the event of a flood. Higher percentages were assigned to impact and risk factors that pose a greater potential detriment to the facilities. In collaboration with the Mass DEP wastewater and drinking water experts, we were able to identify which factors would carry more "weight" than others in the development of the tool. There were certain thought processes we followed in order to develop the weights that we assigned to each factor.

We began by identifying the presence in FEMA Flood Zones and ACE Hurricane Inundation Zones and the elevation of the facility factors as the most important criteria for risk analysis in both systems used for drinking water and wastewater; while also recognizing Membership of Mass WARN and The Elevation of Storage Tanks as the least important factors for wastewater and drinking water respectively. After making these decisions we proceeded to



carefully assess and “weight” the impacts of each factor in between the most important and least important factors with a percentage. This percentage idea developed into the method we used to score the factors for each facility.

### *Scoring Method for Risk Factors*

The final score for the risk factors are designed to provide the facilities with an overall value between zero and 100. The maximum score is 100 (worst possible score) while the minimum score is zero (best possible score). When a score is finalized for a facility, the higher their score, the more at risk they are to the effects of sea-level rise. After the weights were developed for each factor we assigned scoring to them based off of their total weight. The weight of each factor also represents the maximum score possible for each factor.

### *Wastewater*

FEMA Flood Zones have an overall weight of 16% in the tool, giving them a maximum score of 16 for this factor. FEMA Flood Zones show the area that will flood during a 100-year or 500-year storm. There are three possible outcomes; a facility can be in a 100-year flood zone, 500-year flood zone, or be in neither flood zone. If a facility is in neither flood zone it receives a score of zero as this is the best possible outcome. If a facility is in a 100-year flood zone it receives a score of 16 as statistically this is more likely to occur than a 500-year flood. A score of eight is given to a facility that falls within a 500-year flood zone as it is not as detrimental as being in a 100-year flood zone but not as good as being in neither.

ACE Hurricane Inundation Zones are also weighted at 16% of the overall tool and a facility is given a score based on which zone they fall into, if any. ACE Hurricane Inundation Zones show the areas that will flood during different categories of hurricanes. Since the model is elevation-based, the lower category hurricane inundation areas are given a higher score because they have a higher probability of flooding and will also flood at higher category hurricanes. There are five possible outcomes for this factor; a facility can either be in no hurricane inundation zone or be in the inundation zone for a category one, two, three, or four hurricane. If a facility is not in any inundation zone it is assigned the best possible score of zero. A facility in a category four will receive a score of four, a category three is assigned a score of eight, category two is assigned 12, and a category one is assigned a score of 16.

The elevation of a facility is the third highest weighted factor in the tool with a weighting of 15%. The elevation of each facility was determined using GIS software. A box will be placed

around the facility and elevation will be taken at the four corners and at the center. An average elevation will be taken using these five elevations. The facilities receive their score for elevation based on a sliding scale ranging from zero to 15. If the elevation of a facility was at or below mean sea level (MSL), then the facility received a score of 15. However, if the elevation of a facility was above MSL and below 10 meters above MSL a score of 12 was assigned. Between 11 and 20 meters above MSL received a score of nine, between 21 and 30 meters above MSL received a score of six, between 31 and 40 meters above MSL received a score of three, and any facility above 40 meters above MSL received a score of zero.

If a facility had a history of past flooding, there was reason to believe that this could have been considered a good predictor of future vulnerability to flooding. For this reason past flooding was weighted as 8% of the overall score. If a facility has had past flooding they were assigned the maximum score of eight, otherwise they were assigned a score of zero.

The reason that history of past flooding was not weighted higher was because we did not want to falsely place a facility at a higher risk level that have had past flooding, but have taken measures to mitigate future flooding. We have accounted for this by including a factor for whether or not a facility has installed any protective or precautionary structures that will protect their facility in the event of a storm or flood. If a facility has precautionary protective structures they are assigned a weight of zero or seven if they do not have any protective structures.

It is important that a facility's average flow rate is below their design flow. The difference between a facility's design flow and actual flow is the amount of extra flow a facility can handle in the event of a storm. This factor was given a weight of 8% in the tool and was calculated using a ratio. The ratio was calculated as actual flow divided by design flow and multiplied by the total weight of eight. For instance, if a facility's actual flow was half of their design flow they received a score of four and if their actual flow was equal to their design flow they received a score of eight.

Whether a facility had a ground or surface discharge was given a weighting of 7%. A facility could either discharge their treated water into the ground or onto the surface, such as into a marsh. A facility that discharges into the ground is more at risk because the pipe is more likely to back up than a pipe discharging onto the surface. Therefore a ground water discharge is assigned a weight of seven while a surface water discharge is assigned a score of zero.

In the event that a storm causes a facility to lose power they will need to generate power in order to keep up with the flow into the facility. It is important that a facility can produce its own power until power is restored. This is why longevity of a facility's backup power was weighted at 5%. This factor can be scored on a sliding scale from zero to five. If a facility had no backup power and could not operate after losing power they were assigned the maximum score of five. A facility that could produce enough power for up to three days was assigned a score of four, between three and six days was assigned a score of three, between six and nine days was assigned a score of two, between nine and 12 days was assigned a score of one, and any facility that could produce enough power for 12 or more days was assigned a weight of zero.

It was also important for us to take into consideration how much of the facility that could be powered from the backup power. This factor accounts for 5% of the overall tool and was calculated as the percentage of the facility that is operational under backup power multiplied by the weighting of five. If a facility did not have backup power it was automatically assigned a score of five, the maximum score.

Some facilities can be subject to rainfall induced flow during heavy rainfall. If the amount of rainfall induced flow causes a facility to exceed its design flow, then there would be a higher risk of flooding at the facility. This factor made up 5% of the overall weighting in the tool. If a facility was not subject to rainfall induced flow or if their rainfall induced flow did not cause them to exceed their design flow they were assigned a score of zero. If the rainfall induced flow caused them to exceed design flow by up to 10% they were assigned a score of two, between 10 and 50% over design flow were assigned a score of three, between 50 and 100% were assigned a score of four, and any facility whose rainfall induced flow caused them to exceed design capacity by over 100% was assigned the maximum score of five.

Equalization basins allow facility's to handle large amounts of induced flow by storing the raw water before entering the facility. This could help to prevent the facility itself from flooding. Whether or not a facility had equalization basins was assigned a weight of 4% in the tool. If a facility had equalization basins they received a score of zero, if a facility however did not have equalization basins they were given the maximum score of four.

The last factor for wastewater treatment facilities was whether or not the facility was a member of Mass WARN. Being a member of Mass WARN gives a facility access to critical equipment and parts during a time of need. If a pump breaks down at a facility they would be

able to bring in a replacement temporary pump until a permanent one is able to be installed. This risk factor was weighted as 4%. If a facility was a member of Mass WARN they received a score of zero, if however they were not a member they received a score of four.

### *Drinking Water*

Most of the factors for the risk assessment of the drinking water treatment facilities were the same factors used in the risk assessment of the wastewater treatment facilities. However, some of the factors for the drinking water side of the tool were weighted slightly differently than of the wastewater side. Therefore to avoid redundancies, only the factors that were not used for the wastewater facilities will be described in this section. The factors that are the same, but are weighted differently, will be mentioned briefly to quickly illustrate the slight difference from that of the wastewater facility risk assessment tool.

FEMA Flood Zones and ACE Hurricane Inundation Zones were each equally weighted at 16% as they were in the wastewater facility assessment tool. For both types of facility those factors, as well as a facility's elevation, were considered to be the best indicators of a facility's potential risk of flooding. The elevation of a facility was also the third highest weighted factor in the drinking water risk assessment tool with a weight of 15%.

The source of water was very important when considering whether or not a facility was at risk from sea-level rise. If the salinity level in the water were to increase it could contaminate the drinking water and make it undrinkable. There are three types of drinking water sources: surface water (SW), ground water under direct influence from surface water (GWUDI), and ground water (GW). This factor had a weighting of 10% in the tool. If a drinking water facility received its water from either surface water or ground water under direct influence from surface water a score of 10 was recorded. If a facility received its water from a ground water source that was not under direct influence a score of zero was recorded. Many facilities received their water from more than one source. For this reason only the highest score would be recorded. For example, if a facility had two ground water sources and one surface water source, only the score for their surface water source was recorded.

There are many treatment processes that a facility can perform on drinking water. If contaminated or shut down they each would have a different level of difficulty in replacing and restarting these treatment processes. The treatment processes a facility uses had a weight of 10% and considered four different treatment processes: chemical addition, conventional filtration,

direct filtration, and membrane filtration. Chemical addition was assigned a score of two, conventional filtration a score of eight, and direct filtration and membrane filtration received a score of 10. Some facilities use multiple treatment methods in their facilities and as a result only the highest score was recorded.

Record of past flooding occurrences at a drinking water facility held the same weight as at a wastewater facility. This factor was given a maximum weight of 8% and was calculated using the same methodology. As was the supplemental factor of if a facility had installed any protective or precautionary measures to mitigate the effects of flooding at the facility. It was given a maximum weight of 7%.

It is critical that a facility is able to generate their own power in the event that they lose power. The availability of onsite backup power is rated at 5% of the tool. If the facility has onsite backup power they will receive a score of zero while if they do not have onsite power they will receive a score of five.

The amount of time a facility can run on backup power is important in a time of emergency. This is why longevity of a facility's backup power is weighted at 5%. This factor is scored on a sliding scale from zero to five. If a facility has no backup power and cannot operate after losing power they are assigned the maximum score of five. A facility that can produce enough power for up to three days is assigned a score of 4, between three and six days is assigned a score of three, between six and nine days is assigned a score of two, between nine and 12 days is assigned a score of one, and any facility that can produce enough power for 12 or more days is assigned a weight of zero.

After some site visits (summaries in Appendix A), the presence of backup power in a drinking water treatment facility was determined to be less common among the drinking water facilities than the wastewater facilities. For this reason, an additional factor for the drinking water facilities was weighted amongst the factors regarding backup power at a facility. The longevity of backup power that a facility could sustain and how much of the facility could run during a period of backup power use were calculated the same as with the wastewater treatment facilities. These two factors also have the same weight as for the wastewater treatment facilities, a maximum score of five for each.

One of the final and least prominent factors for drinking water treatment facilities was whether or not the facility was a member of Mass WARN. This risk factor held the same criteria

as it did for wastewater treatment facilities and was weighted at 2%. If a facility was a member of Mass WARN they received a score of zero, but if they were not a member they received a score of two.

Finished water storage tanks are usually covered and not subject to inundation unless there is a fault in the tank. However, a finished water storage tanks should not be under water for any reason. The elevation of the finished water storage tanks were weighted at 1% of the overall tool as a less than significant factor, but considered nonetheless. If the bottom of the finished water tank was at or below 10 meters above MSL a score of one was recorded. For an elevation higher than 10 meters above MSL a score of zero was recorded.

## **Application of the Tool**

Our second goal was to apply the finished assessment tool to the random sample of facilities. Once we finalized a list of the selected facilities, we applied the data and information we gathered in order to produce a corresponding risk level and final score for the facility. The completion of two objectives allowed us to achieve this goal. We identified the facilities to which we applied the tool and then we gather the data and specifications for the chosen facilities

### **Identifying Which Coastal Facilities to Assess**

Unfortunately, there were too many facilities along the coast of Massachusetts for us to apply the tool to all of them in the time allotted. The selection process by which we chose the 50 facilities was fairly simple, yet sophisticated. All of the facilities that were selected were within five miles of the coast. This number was chosen as a good distance for us to generate a list with a wide spectrum of facilities that were still in the coastal Massachusetts. We chose to conduct a stratified random sample of facilities for our sample size. This was the best way to present each facility with an equal opportunity for selection, while guaranteeing that each category of water treatment facilities would be represented by at least one facility. Without any direct human input in the selection process, the idea of skewing data for desired results is effectively eliminated. Random sampling has also been found to be the simplest form of selection when attempting to estimate a sampling error.

For drinking water facilities, the first step was to compose a list of towns within five miles of the coast using satellite imagery from Google maps. Once this was completed, the list was then forwarded to a drinking water representative at Mass DEP who provided us with a list

of the drinking water facilities within the list of towns. From there we separated the facilities into three categories; community, transient non-community, and non-transient non-community. A community water system is a public water system (PWS) that serves the same people year-round, such as municipally-owned public water systems. A non-community water system is a PWS that does not generally serve the same people year-round, in the form of transient and non-transient non-community. Transient non-community water systems are non-community PWS that serve different people for more than six months each year, such as convenience stores and rest stops. Non-transient non-community water systems are non-community PWS that serve the same people for at least six months each year, but not year-round. These can be schools, hospitals and factories with their own water supplies. After the separation of the facilities, we put the three lists in an excel spreadsheet where we took a stratified random sample consisting of; 10 community, 10 transient non-community, and 10 non-transient non-community facilities. The stratified sample ensured that we were able to assess different types of facilities. Due to a lack of response to the surveys sent out and difficulty in contacting the proper administrator, five drinking water facilities were removed from the final list of transient non-community facilities.

When selecting the wastewater facilities, we were provided with a list of all of the North East coastal facilities by a wastewater representative at Mass DEP. We then separated the facilities into two categories, municipal and privately owned. After the separation of the facilities, we put the two lists in an excel spread sheet where we took a stratified random sample of; 15 municipal and 15 privately owned facilities. For the same reason we dropped five of the drinking water facilities, five privately owned wastewater facilities were removed from the final list of wastewater facilities. This was also done to keep the sample sizes of each type of facility equal to each other.

Through this process we obtained results from 37 facilities in total. Although the finite population correction for proportion formula requires a sample size of 165 in order for our results to represent the population of all water treatment facilities along the coast of Massachusetts. A sample size of 101 is needed for wastewater facilities and a sample size of 108 is needed for drinking water facilities. The number of facilities we applied the tool to is sufficient for identifying trends throughout our sample, as well as correctly displaying the functionality of the tool. The finite population correction for proportion formula is:

$$n = \frac{N}{1 + N(e)^2}$$

n= Sample size

N= Population Size

e= Level of precision

## Data Collection

Through archival research of Mass DEP's database we confirmed that the data used from the 2011 Team was updated, while gathering new data for the facilities that were not assessed by the 2011 Team. Through the use of GIS we were able to analyze ACE Hurricane maps, FEMA Flood Zone maps and elevation of the facility, which were three of the major factors of the tool. Surveys were also sent out to facilities with specific questions pertaining to data that was required for some of the risk factors, which could not be found within Mass DEP's database or EPA studies that were also provided for us by the Mass DEP. From these methods of data collection, we were able to collect all of the data and information necessary to complete a thorough risk assessment of the sample of facilities using our tool.



## CHAPTER FOUR: DATA COLLECTION AND DISCUSSION

---

In this chapter we discuss the data that was collected from the application of the risk assessment tool to the sample of coastal wastewater and drinking water treatment facilities. As discussed in the methodology, our data collection came from four separate sources:

1. Gathered information from Mass DEP database
2. Acquired information from EPA Analysis
3. Use of GIS
4. Surveys sent to collect remainder of information

Deciding on a sample of facilities was the first step in the application of the risk assessment tool. As stated in the previous chapter, this was done by a stratified random sample of the facilities in coastal Massachusetts. Once the sample was set for Wastewater and Drinking Water facilities, we could proceed to the actual data collection process.

### Mass DEP Database

An analysis of the information in the Mass DEP central database was the first step to the collection of data. After several meetings with the wastewater and drinking water specialists at Mass DEP, Alan Slater and Paul Niman, we were able to collect the data for each facility that was within the database at Mass DEP. The data we gathered pertained to the following risk factors:

- Members of Massachusetts Water and Wastewater Agency Response Network (Mass WARN)
- Water source (drinking water facilities)
- Discharge source (wastewater facilities)

The water sources are the sources of incoming water to the drinking water treatment facilities. For example, a list of the Cambridge Water Department water sources is in Table 1 below. The various types of possible water sources are as follows: surface water (SW), ground water (GW) and ground water under direct influence (GWUDI).

PWS NAME	SOURCE NAME	SOURCE TYPE
CAMBRIDGE WATER DEPARTMENT	MWRA	SW
CAMBRIDGE WATER DEPARTMENT	HOBBS BROOK RESERVOIR LOW	SW
CAMBRIDGE WATER DEPARTMENT	FRESH POND RESERVOIR	SW
CAMBRIDGE WATER DEPARTMENT	STONY BROOK RESERVOIR	SW
CAMBRIDGE WATER DEPARTMENT	HOBBS BROOK RESERVOIR UPPER	SW

**Table 2.** *The water sources of the Cambridge Water Department.(United States Environmental Protection Agency [EPA], 2012)*

To determine the discharge source of the wastewater facilities, we turned to one of the chiefs of the groundwater permitting program, Alan Slater. He then provided us with the necessary information based off on the list of discharge sources of wastewater treatment facilities. For example, we found Scituate Wastewater Treatment Facility to have a surface water discharge (EPA, 2012). Having a surface water discharge source places the Scituate Wastewater Treatment facility at less risk of flooding. This result is due to the less likeliness of infiltration and backing up of the piping that would come with a groundwater discharge source.

### EPA Analysis

The next step in the data collection process was to analyze the data we had from the EPA 2011 analysis of wastewater facilities. The map generated by the EPA contained data for backup power capabilities and flood risk at wastewater treatment plants in Massachusetts. The map contained 12 wastewater facilities from our sample, as well as data for two factors that we have incorporated into the risk assessment tool. The data we used from the EPA map for the wastewater facilities are as follows:

- Percentage of plant operable under backup power
- Number of days operable under backup power

On the EPA map, the risk factors were added as layers of a circle that were color-coded to a facility's self-reported risk. The self-reported data was displayed as a doughnut graph, which can be found in the map's legend in Figure 5 below.

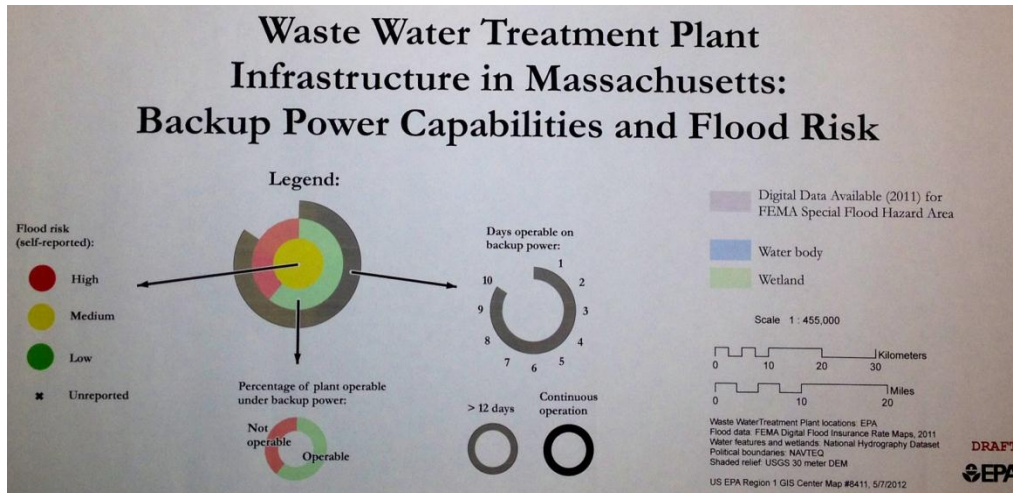


Figure 5. Legend from EPA Analysis Map (EPA, 2011)

From the EPA data we were able to collect backup power information for 12 of the municipal wastewater facilities. The study conducted by the EPA was not specifically focused on coastal facilities, which resulted in the absence of many private facilities we were assessing. Also for this section of data collection, we had to verify that the EPA data was completely up to date. For this reason, when sending out the surveys to all of the facilities, we asked that they either confirmed the data we had pertaining to their backup power capabilities or make the necessary modifications to the data.

## GIS Application

Geographic Information System (GIS) is a layered mapping program for which there are many uses. However, for our project we used GIS to find the following information:

- Elevation of a facility
- Facility presence in a FEMA Flood Zone
- Facility presence in an ACE Hurricane Inundation Zone

GIS allows the user to capture, store, manipulate and analyze geographical data. We added the Elevation layers, FEMA Flood Zones and ACE Hurricane Inundation Zones to the GIS maps that were set up for us at Mass DEP. The FEMA Flood and ACE Hurricane Inundation Zones can be seen in Figure 6. The FEMA Flood Zone represents an area that will flood during a 100-year and 500-year storm, while the ACE Hurricane Inundation Zones display the areas that will flood during different categories of hurricanes.



(a)



(b)

**Figure 6.** (a) Cambridge Water Purification Plant shown in a 500-year FEMA Flood Zone (b) Cambridge Water Department shown in a Category 1 ACE Hurricane Inundation Zone (FEMA, 2012; ACE, 2009)

The Cambridge Water Purification Plant in Figure 6 is a drinking water treatment facility at a high risk level of flooding, falling within an overall risk assessment scoring range of 66 and

100. The Cambridge facility falls within a 500-year FEMA Flood Zone and is within a category 1 ACE Hurricane Inundation Zone.

### Surveys of the Facilities

Finally, we sent surveys to the facilities in order to collect the remainder of data for each risk factor that was not available to us through Mass DEP. We made sure that we only asked the facilities for data that was not gathered before and we did not have in order to keep the survey as short as possible and less time consuming for the survey respondents. Since wastewater treatment facilities and drinking water facilities have different risk factors, we developed separate surveys for each.

In collaboration with our Mass DEP sponsors, the surveys were developed based on data that was not available to us through database research at the Mass DEP or the use of GIS software at Mass DEP. One survey contained data from the EPA that was confirmed by the wastewater facilities, while the other survey had the same questions but did not have any EPA data needing verification. For the facilities that found the EPA data to be inaccurate we provided space for the responders to make the necessary changes. The survey questions for both wastewater and drinking water can be seen in Tables 2 and 3 below, as well as a sample response from one of the facilities.

Survey Questions	Scituate Responses
1. What are your responsibilities at the facility?	I am in responsible charge of both the WWTP and the sanitary collection system.
2. Does your wastewater treatment facility have any equalization basins?	No
3. What are your facility's design flow and actual flow?	Design: 1.6 MGD Average: 1.067 MGD
4. In the case of an emergency does your facility have backup power?	Yes
a. If yes, how long can the backup generator operate without obtaining additional fuel?	1.5 Days
b. What percentage of plant operation will be able to function during this time?	1
5. Is your facility subject to rainfall induced flow?	Yes
a. If Yes, how much does the increase in flow exceed capacity:	Does not Exceed Capacity
6. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?	Yes
a. If yes, please describe:	The Sand Hills Pump Station has been flooded in the past.
7. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)	No
a. If yes, what type of protective or precautionary structures?	
8. Any additional comments or information regarding flood vulnerability?	In Oct.2011 avg. power consumption was 197 kw/hr., our Em.Gen.Set. is 750 kw. $197/750 = 26.3\%$ of load, fuel consumption at that rate would give the WWTP 5.1 days of fuel, not 1.56 days.

Table 3. Wastewater survey question with the responses from the Scituate wastewater facility

Survey Questions	Cambridge Water Department Responses
<b>1. What are your responsibilities at the facility?</b>	Primary Operator, responsible for Plant, Lab and Watershed
<b>2. Which of the following best describes your treatment processes?</b>	Conventional Filtration
___ Chemical addition only	
___ Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)	
___ Direct filtration	
___ Membrane Filtration	
<b>3. What is the elevation of the bottom of your finished water storage tank(s)?</b>	-4.84 Feet above MSL
<b>4. In case of emergency, does your facility own backup power onsite?</b>	Yes
<b>a. If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?</b>	Continuous
<b>b. Approximately what percentage of plant operation will be able to function during this time?</b>	0
<b>5. Has the facility suffered from any past flooding damage?</b>	Yes
<b>a. If yes, please describe:</b>	Internal pipe failure. No external flooding experienced for the existence of the water system.
<b>6. Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)</b>	No
<b>a. If yes, please list what types of protective or precautionary structures below:</b>	
<b>7. Any additional comments or information regarding flood vulnerability?</b>	The City (Cambridge) has just initiated a Climate Change Vulnerability Assessment, the water system will be part of the assessment.

**Table 4.** *Drinking Water survey questions with the responses from Cambridge Water Department*

However, some complications arose in the process of retrieving the actual data from each facility. There were several non-community drinking water and privately owned wastewater treatment facilities that were unresponsive to the surveys we emailed. Also, we also could not reach them through our follow-up phone calls by the deadline we chose for survey responses. To compensate for these facilities that proved to be unresponsive as the deadline approached, we substituted them with stratified random selections. Each facility was given 2 weeks to respond to the short surveys. We agreed with our sponsors who determined that this was an adequate amount of time for a facility to gather their information and complete the survey.

At the end of the data collection period we completely assessed 23 representative wastewater facilities and 14 drinking water treatment facilities. Although we were not able to retrieve data from our initial desired 50 facilities, there is still enough data to show the functionality of the tool.

## Risk Assessment Results

Once we applied the tool to the samples of facilities, we were able to calculate their overall score.

<b>MUNICIPAL WASTEWATER FACILITIES</b>	<b>FINAL SCORE</b>
<b>BARNSTABLE WWTP</b>	<b>41.81</b>
<b>Chatham</b>	<b>34.60</b>
<b>Dartmouth Water Pollution Division</b>	<b>28.38</b>
<b>Falmouth</b>	<b>32.33</b>
<b>Hull</b>	<b>53.80</b>
<b>Kingston</b>	<b>32.58</b>
<b>Lynn c/o U.S. Filter</b>	<b>56.82</b>
<b>Manchester By The Sea</b>	<b>54.80</b>
<b>Moles Environmental Services, Inc.</b>	<b>32.60</b>
<b>MWRA – Deer Island Plant</b>	<b>37.27</b>
<b>Nantucket (Surfside)</b>	<b>44.97</b>
<b>New Bedford</b>	<b>50.29</b>
<b>Oak Bluffs</b>	<b>37.64</b>
<b>Salisbury</b>	<b>33.62</b>
<b>Scituate</b>	<b>68.34</b>
<b>Plymouth (Veolia water)</b>	<b>33.00</b>

*Table 5. Final risk scores for municipal wastewater facilities*



<b>PRIVATELY OWNED FACILITIES IN SOUTH EAST MASS</b>	<b>FINAL SCORE</b>
<b>PILGRIM POWER STATION</b>	<b>51.85</b>
<b>AUTOMATIC COIN LAUNDRY</b>	<b>50.88</b>
<b>BLACK ROCK GOLF COMMUNITY</b>	<b>47.57</b>
<b>LINDEN PONDS AT HINGHAM</b>	<b>48.40</b>
<b>SPYGLASS LANDING</b>	<b>25.13</b>
<b>PLYMOUTH SOUTH HIGHSCHOOL</b>	<b>29.00</b>
<b>WHITE CLIFFS CONDO</b>	<b>29.50</b>

*Table 6. Final risk scores for privately owned wastewater facilities in South East Massachusetts*

<b>COMMUNITY PUBLIC WATER SYSTEM</b>	<b>FINAL SCORE</b>
<b>CAMBRIDGE WATER DEPARTMENT</b>	<b>74.5</b>
<b>DARTMOUTH WATER DIVISION</b>	<b>57.0</b>
<b>EDGARTOWN WATER DEPARTMENT</b>	<b>49.0</b>
<b>MASHPEE WATER DISTRICT</b>	<b>36.0</b>
<b>NEWBURYPORT WATER DEPARTMENT</b>	<b>50.0</b>
<b>PLEASANT WATER</b>	<b>21.0</b>
<b>NORWELL WATER DEPARTMENT</b>	<b>48.0</b>
<b>WESTPORT SENIOR VILLAGE</b>	<b>35.0</b>

*Table 7. Final risk scores for community PWS*

<b>TRANSIENT NON-COMMUNITY PUBLIC WATER SYSTEM</b>	<b>FINAL SCORE</b>
<b>PINEWOODS CAMP INC.</b>	<b>20</b>
<b>SEATOLLER</b>	<b>47</b>

*Table 8. Final risk scores for transient non-community PWS*

<b>NON-TRANSIENT NON-COMMUNITY PUBLIC WATER SYSTEM</b>	<b>FINAL SCORE</b>
<b>PLYMOUTH SOUTH HIGH SCHOOL</b>	<b>16.0</b>
<b>THE BAIRD CENTER</b>	<b>20.0</b>
<b>THE NEW TESTAMENT CHURCH</b>	<b>33.0</b>

*Table 9. Final risk scores for non-transient non-community PWS*

## Discussion

Although our data does correctly display the functionality of the tool, it does not represent the overall population of facilities within each designated category. As sample size reaches a number closer to the population, the data collected becomes a more accurate representation of the population (Hall, Herron, Pierce, Witt, 2001, pp 169-185). The data that we were able to collect shows trends among the facilities sampled, rather than absolute values of the overall population.

Of the 134 wastewater treatment facilities along the coast of Massachusetts, we were able to collect data and assess 23 facilities. Using the Finite Population Correction for Proportion to calculate sample sizes for a given population, we found that for an accurate representation of the average risk level of wastewater facilities, an assessment of 101 facilities is required (Israel, 2009). However, after several meetings with our sponsors at the Mass DEP, we found that the likelihood of receiving 101 responses within the time allotted was very low. We then decided that setting a goal of receiving data from 20-30 facilities would be sufficient for displaying the functionality of the tool, as well as illustrating trends between wastewater facilities through graphs and charts.

The process used to obtain our sample size for drinking water was similar to that of the wastewater process. After identifying the 146 drinking water facilities along the coast of Massachusetts, we set our sample size to reflect that of the wastewater facilities at 20-30 facilities. In collaboration with our sponsors we determined that data from 20-30 facilities was an achievable goal. A sample size of 20-30 facilities also allows us to show the functionality of the tool for drinking water facilities the same way it did for wastewater, by allowing us to display trends among the responding facilities. However after receiving only 14 responses from the drinking water facilities in total, it makes it difficult to separate the facilities into their categories to show trending data. For example there is not sufficient data between the transient non-community and the non-transient non-community facilities to make trending relations within their respective categories. In order to present our data as a representation of the entire population of drinking water facilities along the coast, a sample size of at least 108 is required using the Finite Population Correction for Proportion equation for a population of 146 (Israel, 2009).

Through an observation of the data, it can be concluded that the average risk score for municipal wastewater treatment facilities is 37.685, from a sample size of 15 facilities. In regards to the sample we surveyed of wastewater treatment facilities along coastal Massachusetts, this mean value of 37.685 shows that these facilities are generally at a lower risk for flooding from the rising sea level. The privately owned wastewater treatment facilities in southeastern Massachusetts received an average risk score of 40.33 for a sample size of seven. Therefore, the privately owned coastal wastewater treatment facilities we surveyed are at a slightly higher risk of flooding, but still within the “medium” category for flood risk. From the data we collected, an average risk score of 47.31 was observed for community drinking water treatment facilities from a sample size of eight facilities. These facilities are at a medium risk of flooding from the rising sea level. Unfortunately the sample size of two and three for the transient and non-transient non-community drinking water treatment facilities respectively, was too low to determine an accurate average risk score for the overall population of the two types of facilities. Due to the small sample size of the facilities, the averages are not representative of the overall population but rather show only a trend of our sample.

After consolidating all of the data we received from each facility, we assessed a total of 37 facilities, and packaged the results of each facility into concise result sheets that can be found in Appendix D. Since the tool is based on a scale of 0 to 100, we divided the range into three categories of low, medium, and high. A final score of 0 to 33 indicates a low risk level, greater than 33 to 66 indicates a medium risk level, and any score greater than 66 indicates a high risk level.

The two highest-weighted risk factors, whether or not a facility is in a FEMA Flood Zone or ACE Hurricane Inundation Area, together make up 32% of the overall weighting for the tool. These two risk factors are associated with facilities scoring higher on the scale. Since the scale for the scoring is separated into 33 point increments, scoring the maximum points for both FEMA and ACE can raise a facilities score nearly one level (Low, Medium, and High). If a facility scores the highest on both FEMA and ACE they will almost certainly receive a minimum final score in the medium risk-level range. However, because it is necessary for cities and towns to have access to both a drinking and wastewater facility, sometimes the city’s location requires that a facility be built in one of these areas. It is also possible that when a facility was originally constructed it was outside of both FEMA Flood

Zones and ACE Hurricane Inundation Areas. This is because FEMA Flood Zones and ACE Hurricane Inundation Areas are adjusted over the years as the climate changes.

Another risk factor that is associated with a higher overall score is the elevation of the facility. The elevation of a facility is scored at 15% of the overall weighting of the tool. Since we developed a tool for coastal facilities it is not uncommon to have a facility that has a low elevation relative to mean sea level. Since every house needs access to drinking water and wastewater facilities, a facility might have to be constructed at a low elevation simply because there is not an area around that is very high above mean sea level. From here a facility would have to take preventative measures in order to mitigate the effects in the event of a flood.

Facilities with a medium score tended to score lower on both FEMA Flood Zones as well as ACE Hurricane Inundation Zones. This is crucial for facilities since these two risk factors accumulate to 32% of the tool. Medium scoring facilities scored a wide range of scores for their elevation.

Low scoring facilities tended to score below average on FEMA Flood Zones, ACE Hurricane Inundation Zones, and elevation. These three factors combined make up 47% of the overall tool. If a facility is able to score zero points on these three risk factors then the maximum possible score they could receive is 53. Each facility along the coast should strive towards lowering their risk level and adapt to the changing climate because the social implications of a flooded facility has the potential to be devastating.

The social implications of a flooded wastewater and drinking water facility prove to be detrimental. In the event that a wastewater facility were to flood this would pose many health and hazards for cities and towns. A flooded wastewater facility may lead to backed up sewer pipes causing an overflow of pipes, which may result in blown manhole covers. These blown manhole covers will lead to the discharge of raw sewage and other toxic chemicals in the streets of cities and towns, as well as the backyards of many homes along the coast of Massachusetts. The discharge of raw sewage is not only a health hazard towards humans, but also has the potential to destroy plant life and the habitats of creatures and animals that inhabit the area within the vicinity of the discharge. With the clean-up of raw sewage discharge, the repairs and replacements of pipes that were damaged due to the flood, this will prove to be a costly process for any given facility.

In the event that a drinking water facility were to flood, the social implications may be even greater than that of a flooded wastewater facility. If a drinking water facility were to flood, many homes along the coast would be provided with either poor water quality or no water at all. Those families that do receive some water after a flooded water facility may result to boiling their own water to ensure cleanliness. The consumption of untreated water may cause stomach viruses and other various ailments. In the event that a drinking water facility was to shut down due to flooding, it would create many inconveniences for the population that it serves. Families would be forced to make frequent stops to their local supermarkets to purchase gallon water for drinking and bathing. The financial aspect of a flooded drinking water facility is similar to that of wastewater. Facility managers will have to conduct an assessment of their entire facility to make the necessary repairs and replacements of areas that were damaged during the flood. However drinking water facilities will also have to ensure that their filtration systems are operating at one hundred percent to guarantee the proper sanitation is being provided to the water. If drinking water facilities are unable to provide properly sanitized water to the public, local businesses would suffer and this would have an economic effect. For example, local restaurants that need to be provided with clean water on a regular basis would no longer receive sanitized water, resulting in the restaurant being forced to shut down.

The tool and resulting analyses, acts as a reference to help the facilities take proactive measures to mitigate the impact of flooding due to the rising sea level. The information generated by the tool will be useful for a variety of stakeholders with influence or authority over actions taken at the facilities, in order to reduce their risk of flooding. Mitigating actions may range from installing sea-walls and other physical protective structures, to creating a new budget plan or policy concerning the financial aspect of adaptation to the changing climate.

## CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

---

In this chapter, we present our concluding statements and recommendations to the Massachusetts Department of Environmental Protection (Mass DEP), other municipalities looking to perform similar types of analysis, and to stakeholders. We begin by discussing some of the common risk factors that are associated with higher scoring facilities. Next, we describe some actions that facilities can take in order to reduce their overall risk level score. Lastly, we will present recommendations that can be implemented to improve the effectiveness of the tool as well as the findings of this report. We believe that the Massachusetts Coastal Water Treatment Facility Risk Assessment Tool effectively measures the risk a facility faces to due rising sea-levels.

### Conclusion

In collaboration with the Mass DEP, the development of the Massachusetts Coastal Water Treatment Facility Risk Assessment Tool will effectively aid wastewater and drinking water treatment facilities to mitigate the negative effects of climate change. As sea-level continues to rise, the need for climate change adaptation by wastewater and drinking water facilities becomes imperative. We have successfully assessed 37 wastewater and drinking water facilities, and determined their risk level according to our tool. Once a risk value was calculated, each facility was labeled with a rank of “high”, “medium”, or “low”. Along with the tool we have developed the Result Sheets for the facilities that participated and will serve as great visual representations of the overall risk scores of each facility. The Result Sheets will be helpful for assigning priority to the facilities at greater risk of flooding and serve larger populations. Through our development of the tool and our packaged findings, facilities will be provided with multiple recommendations to adapt to the changing climate in order to mitigate its effects, specifically flooding caused by the rise in sea level.

### Recommendations

Not only did we accomplish our goals, we exceeded them through the development of our result sheets for every facility we assessed, as well as the development of the Risk Assessment Tool Summary Sheets we created which can be found in Appendix D. The Risk Assessment Tool Summary Sheets that we developed serve as a detailed explanation of the

scoring method behind each factor. However there is always room for improvement. In the event that Mass DEP desires to further advance the tool, below are our recommendations to them, as well as to the facility managers who intend to take action towards mitigating the effects of climate change at their facility.

## **Recommendations for Mass DEP**

Although we were able to assess 37 facilities in total, there are 243 facilities along the coast of Massachusetts that were not assessed. Our recommendation to the Massachusetts Department of Environmental is that the tool be applied to all of the facilities along the coast. By applying the tool to all of the coastal facilities, the Mass DEP will be able to collect more results from the application of the tool and ensure its accuracy or make the necessary adjustments where they see fit. A wider application of the tool also allows for statistical analysis of the data and results. For example we noticed a positive correlation of 0.75 between the risk level of drinking water facilities and the population they served, however we could not present the information as no more than a trend. Through The Finite Population Correction for Proportions with a confidence level of 95% (Israel, 2009), an assessment of 101 and 108 facilities is required for the data to be representative of the entire population of wastewater and drinking water facilities respectively, along the coast of Massachusetts. If data for drinking water and wastewater treatment facilities were aggregated a sample size of 165 would be required for a confidence level of 95% (Israel, 2009). Finally, with the application of the tool on all of the facilities, each facility will be provided with their overall risk score as well as recommendations towards lowering their Risk Score once they receive their personalized Result Sheet.

In addition to the coastal facilities, a great advancement for the risk assessment tool would be the expansion of its applicability to inland treatment facilities. At first glance it may seem unnecessary to conduct a risk assessment of flooding for a facility that is not along the coast of Massachusetts, but there are other flood risks created due to the changing climate that are not solely a result of sea-level rise. For instance, another major product of climate change is its effect on weather patterns and storm surges. Rainfall has been projected to double in frequency in North America (Waters, Watt, Marsalek, Anderson, 2003, p. 756). Climate change has led to an increase in storm surges as well as heavier rainfall. Though the rising sea level may not be an integral factor to potential flooding of an inland facility, a heavy rain storm could cause

flooding. The possibility of increased rainfall and storm surges may pose a threat of flooding for both low-lying facilities as well as facilities that are higher in elevation that believe they are not at a risk of flooding. With the potential for Mass DEP to adjust the factors and their corresponding weights, the risk level of inland facilities to flood due to climate change may be calculated. This may also give the inland treatment facilities additional resources to acquire assistance in adapting to the changing climate.

In collaboration with the experts at Mass DEP the weightings for each of the risk factors represent our best judgment as to their importance in contributing to the risk of flooding a facility faces due to sea-level rise. Throughout the project the weightings of the risk factors were changed many times as we held discussions and gathered input from our experts at the Mass DEP and regional officer. Past flooding was the most debated risk factor as we received input to both increase its weighting and to keep it unchanged. All of the feedback we received from our sponsors encouraged us to adjust the weightings of the risk factors as we heard supporting arguments in order to get as close to the true value a risk factor holds. We encourage the Mass DEP and other agencies to continue to discuss the risk factors and their weightings. The further refinement of the weightings over time will help to create a more polished tool and an accurate representation of a facilities risk level of flooding due to sea-level rise.

## **Recommendations to the Facilities**

A trend amongst the highest scoring facilities was their location in FEMA Flood Zones and ACE Hurricane Inundations areas, there are still pro-active measures that plant managers may take in order to mitigate the effects of climate change. Suggesting a facility to relocate is an unreasonable request. However, in order to reduce the likelihood of a flood, all facilities should build protective structures. This will not only decrease their overall flood risk score, but will be a physical obstacle that will essentially prevent flood waters from entering areas that house crucial features of the facility. The facilities who have had experience with past flooding may use their occurrences as blue prints to develop these protective structures in the areas that were impacted by the flood waters. Other factors that will effectively lower the flood risk score of a facility are an increase in backup power, elevation of critical equipment, and a membership to the Massachusetts Water and Wastewater Agency Response Network (Mass WARN). By increasing



the backup power, facilities will be able to run longer on backup power and reduce their likelihood of having to shut down the facility.

Through our discussions with facilities we became aware that quite a few of the facility managers did not believe in climate change or that their facility would be effected by climate change. Since they do not believe climate change exists it is believed that they would not take voluntary actions in order to mitigate their risk to climate change and sea-level rise. We believe it would be beneficial to the facilities' future to be required to budget for climate adaptation as well as future emergencies. Future emergencies may include flooding at a facility or the event of a hurricane. Budgeting for an emergency could require a facility to have cash reserves that are easily accessible in the event of an emergency. Budgeting for climate change is more difficult, since each facility is at a difference risk level based on our tool. It would not make sense to require a facility with a score of 16 to develop the same plan as a facility that received a score of 80 in response to climate change. There are many options when creating a policy requiring facilities to adapt to climate change. This could include requiring facilities to budget for climate adaptation based on the risk level score they received. A facility with a higher score would then be required to set aside more of their budget to adaptations. This example is just one option of many different possible policies that could be implemented. We believe that a facility should take actions to adapt to climate change in order to mitigate their risk as much as possible, ensuring they have fewer emergencies in the future.

## Summary

The above recommendations help to further advance the tool as well as to help protect the facilities and mitigate their risk of flooding due to sea-level rise. Currently the tool is a solid foundation that allows facilities and stakeholders to understand the risk a facility currently faces due to the rising sea-level. By implementing our recommendations both facilities and the communities in which they serve will be better protected in the future from increasing storm surges and flooding events. It is beneficial for the facilities and the community for drinking water and wastewater facilities to adapt and prepare for future climatic events.

## BIBLIOGRAPHY

---

Abel, D. (2012, Jun 25, 2012). Rising sea level a threat to east. *Boston Globe*. Retrieved from <http://search.proquest.com.ezproxy.wpi.edu/docview/1021953470?accountid=29120>

*Annual public water system awards*. (2011). Retrieved 3/24, 2012, from <http://www.mass.gov/dep/water/drinking/awards.htm>

Army Corps of Engineers, ACE Hurricane Inundation Zones, 1:5000, ArcGIS

Bernstein, L., Bosch P., Canziani O., Zhenlin C., Christ R., Davidson O. . . . Yohe G. (2007). *Climate change 2007: Synthesis report*. Retrieved from [http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4\\_syr.pdf](http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf)

Blumenau, A., Brooks, C., Finn, E., & Turner, A. (2011). *Effects of sea level rise on water treatment & wastewater treatment facilities*. (Interactive Qualifying Project No. 41-JPH B113). Worcester Polytechnic Institute: Worcester Polytechnic Institute.

Bray, M., Hooke, J., & Carter, D. (1997). Planning for sea-level rise on the south coast of england: Advising the decision-makers. *Transactions of the Institute of British Geographers*, 22(1), pp. 13-30. Retrieved from <http://www.jstor.org/stable/623048>

Carpenter, S. R., Fisher, S. G., Grimm, N. B., & Kitchell, J. F. (1992). Global change and freshwater ecosystems. *Annual Review of Ecology and Systematics*, 23, pp. 119-139. Retrieved from <http://www.jstor.org/stable/2097284>

Colle, B. (2008). NEW YORK CITY'S VULNERABILITY TO COASTAL FLOODING. *Bulletin of the American Meteorological Society*, 89(6), 829.

Davis, M. L., & Masten, S. J. (2009). Principles of environmental engineering and science (2nd ed.). New York, New York: McGraw-Hill.

Dinicola, K. (2009). *The "100-year flood"*. (Fact Sheet No. 229-96). Tacoma, WA: U.S. Geological Survey.

- EPA. (2004). *Drinking water treatment* . Retrieved from  
[http://www.epa.gov/ogwdw/sdwa/pdfs/fs\\_30ann\\_treatment\\_web.pdf](http://www.epa.gov/ogwdw/sdwa/pdfs/fs_30ann_treatment_web.pdf)
- Federal Emergency Management Agency, FEMA Flood Zone, 1:5000, ArcGIS
- Greenhouse gases*. Retrieved 4/18, 2012, from <http://www.ens.dk/en-US/ClimateAndCO2/ClimateChange/GreenhouseEffect/GreenhouseGases/Sider/Forside.aspx>
- Hall, T. W., Herron, T. L., Pierce, B. J., & Witt, T. J. (2001). The effectiveness of increasing sample size to mitigate the influence of population characteristics in haphazard sampling. *Auditing*, 20(1), 169-185. Retrieved from  
<http://search.proquest.com.ezproxy.wpi.edu/docview/216738387?accountid=29120>
- Heberger, M., California. Dept. of Transportation., California. Metropolitan Transportation Commission., California Energy Commission., California Environmental Protection Agency., Pacific Institute., . . . California Climate Change Center. (2009). *The impacts of sea-level rise on the california coast*. Retrieved
- Intergovernmental Panel on Climate Change. (2007). Intergovernmental panel on climate change fourth assessment report. Working group 1 report: the physical science basis. Retrieved March 24, 2012, from <http://www.ipcc.ch/ipccreports/ar4-wg1.htm>
- Israel, G. D. (2009). *Determining sample size*. Retrieved 10/11/12, 2012, from  
<http://edis.ifas.ufl.edu/pd006>
- Nicholls, R. J., Hoozemans, F. M. J., & Marchand, M. (1999). Increasing flood risk and wetland losses due to global sea-level rise: Regional and global analyses. *Global Environmental Change*, 9, Supplement 1(0), S69-S87. doi: 10.1016/S0959-3780(99)00019-9
- Pachauri, R. K., & Reisinger, A. (2007). *Climate change 2007: Synthesis report*. (). Retrieved from [http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4\\_syr.pdf](http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf)
- State of Washington. *What is climate change?* Retrieved 3/28, 2012, from  
<http://www.ecy.wa.gov/climatechange/whatis.htm>

- Stevens, A., & Collins, L. (2011). Development and application of GIS datasets for assessing and managing coastal impacts and future change on the central coast of western Australia. *Journal of Coastal Conservation* ] 15, 671-685.
- Tucci, C. E. M. (2004). Flood management in Curitiba metropolitan area., 1.
- United States Environmental Protection Agency. (2012). *Massachusetts final individual permits*. Retrieved 10/3, 2012, from [http://www.epa.gov/region1/npdes/permits\\_listing\\_ma.html](http://www.epa.gov/region1/npdes/permits_listing_ma.html)
- WATERS, D., WATT, W. E., MARSALEK, J., & ANDERSON, B. C. (2003). Adaptation of a storm drainage system to accommodate increased rainfall resulting from climate change. *Journal of Environmental Planning and Management*, 46(5), 755-770. doi: 10.1080/0964056032000138472
- Whittaker, A. (2007). Wastewater treatment: Advanced suspended growth technology. *Filtration & Separation*, 44(9), 19-21. doi: 10.1016/S0015-1882(07)70282-3

## APPENDIX A: FACILITY VISITS

---

### Site visit to Hull Wastewater Treatment Plant

**Attendees: Tony Cangelo, Nic Dupuis, Asher Plange, Alan Slater, Dan (plant operator)**

**10:00 AM on Friday, September 7, 2012**

- Bad storm in 1978 (flooded the facility)
  - During original construction of the facility – went under water, dykes let go
  - Lost pumps, motors, etc.
  - This was the last time the facility was flooded
  - Build flood gates to prevent it from happening again
- First step is to pump out sludge
  - Get liquid content to about 4-5%
  - Pump into sludge tank (holds about 10 ft of sludge) which is shipped weekly to Rhode Island to be incinerated
- Someone runs through a daily checklist at the end of the workday
- Next step is grit removal
  - About 20 pounds of grit per day (also picked up weekly)
- There are primary and backup generators, which run/ can run everything
  - Backup can run facility for about 3-4 days
- There are 2 primary tanks (1 is offline for now)
- Aeration tanks 1 and 3 are running, while 2 and 4 are not (there in case of emergency/ cleaning)
- Secondary pumps send scum to thickener
- Finally they highly chlorinate the water, then dechlorinate (with sodium bisulfate) so it can be discharged into the ocean
- Extremely close to ocean
- In the event of an emergency, feeling is it can be handled

## Site visit to Scituate Wastewater Treatment Plant

Attendees: Tony Cangelo, Nic Dupuis, Asher Plange, Alan Slater, Bob Rowland

1:00 PM on Friday, September 7, 2012

- Facility has many additions, such as Septage and Dewatering buildings
  - Also changed from secondary to tertiary treatment in 2000 (adds denitrification)
  - Design flow increased from 1 MGD to 1.6 MGD
- The bar racks collect large debris like rags (rises in elevation to collect them)
- There is lab work conducted daily, weekly and monthly (conductivity, height of settled materials, ironide, etc.)
- Redundant equipment (pumps) are helpful, in case of breakdowns
- Clarifiers (mechanism turns clockwise and collects smaller debris)
- No longer a groundwater discharge facility (sand filters)
- Treatment plant and pump stations have backup generators
  - Went from gas to diesel (could run for 4-5 days)
- Old plant used chlorine. Moved to UV light (screws up DNA of bacteria so it cant reproduce)
- Denitrification filter
  - Oxidizes nitrates ( $N_3$ ) and nitrites ( $N_2$ ) to nitrogen gas
  - Needs carbon (methanol injection uses up any available oxygen)
- Required to do 3 fecal testing's a day (post-aeration tanks covered because of bird's pooping)

## Site visit to Worcester Drinking Water Treatment Plant

Attendees: Tony Cangelo, Nic Dupuis, Asher Plange, Alan Slater, Dan (plant operator)

10:00 AM on Thursday, September 13, 2012

- The plant puts out about 50 MGD
- Started in 1997
- No dehumidifiers, stainless steel input pipes (insulated)
- Two pressure readers check inflow
- Mirror image plant (two sides - identical)
  - Can shut off half of plant and still run other half
- Use ozone for filter (also for taste and odor)
- Spare for every piece of equipment (except emergency generator)
- Cooling drops temperature, which causes condensation (builds moisture)
- Then dry the air -> into dielectric tubes (increase Hertz) for plasma effect
  - Can make > 2% ozone ( $O_2 \rightarrow O_3$ ) to mix into water
- Coagulants (alum and polymer)
  - Rapid mix goes to flocculators (slower mixing)
- Renewables (solar power) produce about 10% of plants' power (60-70 kW)
- Water flows by gravity down through layers of sedimentary material (gravel, sand, coal, etc.)
- Anything floating is backwashed (doesn't affect filter)
- Biggest downside of ozone is cost of electricity to run it
- Emergency MWRA (can get 15 MGD in case of drought)
- O&M Manuals
- 2 tanks of alum and polymer
  - 1 for each side of the plant (plus extra middle pump in case defective pumps on either side)
- Backup generator is gas-fired (unlimited feed)
  - Longest run for 14 days straight
- Use chlorine gas treatment

## APPENDIX B: SURVEYS TO THE FACILITIES

---

NOTE: Below is the cover letter for the wastewater surveys. All of the wastewater surveys were addressed with this cover letter on the first page.



Commonwealth of Massachusetts  
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

One Winter Street Boston, MA 02108 • 617-292-5500

DEVAL L. PATRICK  
Governor

TIMOTHY P. MURRAY  
Lieutenant Governor

RICHARD K. SULLIVAN JR.  
Secretary

KENNETH L. KIMMELL  
Commissioner

### Waste Water Facility Flood Vulnerability Survey

Monday, September 17, 2012

Dear Waste Water Treatment Plant Operator:

The Massachusetts Department of Environmental Protection, in collaboration with Worcester Polytechnic Institute, is developing a screening tool to quantify the relative risk a given facility faces. Once finished, the tool can be applied to treatment facilities to identify relative risk of flooding from sea level rise. We ask you to take the time to fill out the following brief survey, which should require no more than ten minutes to complete. Your help is greatly appreciated.

There will be no adverse consequences to you or the facility for responding. Data collected for this project will be used to develop this climate adaptation screening tool in order to identify the risk a given facility faces due to the rising sea level, and encourage facilities to undertake risk reduction measures. The results of this tool may be used voluntarily by a facility to plan for facility modifications and present stakeholders (including municipal boards) with information about the facility's risk level from sea level rise and flooding. We hope the results will also be used by stakeholders to take proactive actions in order to mitigate the potential impacts.

We would like to thank you in advance for taking the time to assist us by answering the short survey. If you require additional information or have questions, please contact us at the email addresses or phone numbers listed below. Please return the completed survey as soon as possible via email to [NDupuis@state.ma.us](mailto:NDupuis@state.ma.us). A representative of the project will be contacting you by phone by Wednesday, September 19<sup>th</sup>, 2012.

Sincerely,

Ann Lowery  
Deputy Assistant Commissioner  
Bureau of Resource Protection



## Wastewater Facility Surveys

The wastewater surveys were separated into two types in order to confirm the information we had received from the EPA study on backup power generation at wastewater treatment facilities, while also retrieving the data from the facilities for which we still did not have the data.

### Barnstable (with EPA)

#### Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** Andrew Boule

**Title:** Laboratory Technician

**1. What are your responsibilities at the facility?**

Laboratory testing, reporting, sampling, process control

**2. Does your wastewater treatment facility have any equalization basins?**

Yes  No (We have spare clarifiers)

**3. What are your facility's design flow and actual flow?**

4.2 MGD Design Flow 1.2 to 2.0MGD (seasonal) Actual (Average) Flow

**4. Mass DEP has information about your plant's backup power. Please confirm or correct the following information:**

**a. In the case of an emergency does your facility own backup power?**

Yes  No (DEP data: Yes)

**a. If yes, how long can the backup generator operate without obtaining additional fuel?**

2 Days \_\_\_ Hours

(DEP data: 3 Days)

- b. Approximately what percentage of plant operation will be able to function during this time?

100 %

(DEP data: 100% )

5. Is your facility subject to rainfall induced flow?

Yes \_\_\_ No (No more than 25% in extreme rainfall events)

- a. If Yes, how much does the increase in flow exceed capacity:

0-10% \_\_\_ 11-50% \_\_\_ 50-100% \_\_\_ >100%

6. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?

\_\_\_ Yes  No

(DEP data: Yes )

- a. If yes, please describe:

7. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)

\_\_\_ Yes  No

- a. If yes, what type of protective or precautionary structures?

8. Any additional comments or information regarding flood vulnerability?

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## Chatham (with EPA)

### Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** \_\_\_\_\_ Michael Keller \_\_\_\_\_

**Title:** \_\_Chief wastewater operator\_\_\_\_\_

**9. What are your responsibilities at the facility?**

Daily operations

**10. Does your wastewater treatment facility have any equalization basins?**

Yes  No

**11. What are your facility's design flow and actual flow?**

2 MGD \_\_\_\_\_ Design Flow  .150 MGD \_\_\_\_\_ Actual (Average) Flow

**12. Mass DEP has information about your plant's backup power. Please confirm or correct the following information:**

**a. In the case of an emergency does your facility own backup power?**

Yes  No (DEP data: Yes)

**c. If yes, how long can the backup generator operate without obtaining additional fuel?**

6 Days  Hours (DEP data: 8 Days)

**d. Approximately what percentage of plant operation will be able to function during this time?**

100 % (DEP data: 100%)

**13. Is your facility subject to rainfall induced flow?**

Yes  No

a. If Yes, how much does the increase in flow exceed capacity:

0-10%  11-50%  50-100%  >100%

Does not exceed

**14. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

(DEP data: No )

a. If yes, please describe:

**15. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

b. If yes, what type of protective or precautionary structures?

**16. Any additional comments or information regarding flood vulnerability?**

Significant storm surges would cause problems.

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

**Dartmouth (with EPA)**

**Wastewater Treatment Facility Flood Vulnerability Survey**

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** \_\_\_Carlos Cardoso\_\_\_\_\_

**Title:** \_\_\_Plant manager\_\_\_\_\_

**17. What are your responsibilities at the facility?**

Run facility

**18. Does your wastewater treatment facility have any equalization basins?**

\_\_\_ Yes  No

**19. What are your facility's design flow and actual flow?**

\_\_\_4.2\_\_\_ Design Flow \_\_\_2.3\_\_\_ Actual (Average) Flow

**20. Mass DEP has information about your plant's backup power. Please confirm or correct the following information:**

**a. In the case of an emergency does your facility own backup power?**

Yes \_\_\_ No (DEP data: Yes)

**e. If yes, how long can the backup generator operate without obtaining additional fuel?**

\_\_\_Continuous\_\_\_ Days \_\_\_ Hours (DEP data: Continuous)

**f. Approximately what percentage of plant operation will be able to function during this time?**

\_\_\_100\_\_\_ % (DEP data: 100% )

**21. Is your facility subject to rainfall induced flow?**

Yes  No

**a. If Yes, how much does the increase in flow exceed capacity:**

0-10%  11-50%  50-100%  >100%

5.75/4.2

**22. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

(DEP data: No )

**a. If yes, please describe:**

**23. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

**c. If yes, what type of protective or precautionary structures?**

High Walls

**24. Any additional comments or information regarding flood vulnerability?**

Need the town to proceed in cutting down on rain in-flow. (\$10.6 million)

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

**MWRA - Deer Island (with EPA)**

**Wastewater Treatment Facility Flood Vulnerability Survey**

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:**  Daniel O'Brien

**Title:**  Director, Deer Island Treatment Plant

**25. What are your responsibilities at the facility?**

Senior management person on-site - Responsible for all operation and maintenance

**26. Does your wastewater treatment facility have any equalization basins?**

Yes  No

**27. What are your facility's design flow and actual flow?**

1270 Primary, 700 Secondary          Design Flow 360          Actual (Average) Flow

**28. Mass DEP has information about your plant's backup power. Please confirm or correct the following information:**

**a. In the case of an emergency does your facility own backup power?**

Yes  No (DEP data: Yes)

**g. If yes, how long can the backup generator operate without obtaining additional fuel?**

30 Days          Hours (DEP data: 30 Days)

**h. Approximately what percentage of plant operation will be able to function during this time?**

100 % (DEP data: 100%)

**29. Is your facility subject to rainfall induced flow?**

Yes  No

a. If Yes, how much does the increase in flow exceed capacity:

0-10%  11-50%  50-100%  >100%

**30. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

(DEP data: No )

a. If yes, please describe:

Note - Winthrop causeway can flood in extreme conditions – we try to schedule around the tides if that is a problem

**31. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

d. If yes, what type of protective or precautionary structures?

Yes – Seawalls on eastern shore, Riprap on western shore

**32. Any additional comments or information regarding flood vulnerability?**

Plant was designed in the late 1980's using FEMA maps for 25- and 100-year flood elevations plus additional protection to account for sea level rise.

Note – This response is for Deer Island only- not other MWRA WW Facilities

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!



## Hull (with EPA)

### Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at MassDEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** Jim Dow

**Title:** Chief Facility Manager, Hull Waste Water Treatment Plant

**1. What are your responsibilities at the facility?**

Ensure contract compliance with the contract operations company to maintain and operate the Town of Hull Waste Water Treatment Plant and collection system.

**2. Does your wastewater treatment facility have any equalization basins?**

No

**3. What are your facility's design flow and actual flow?**

Design Flow - 3.07mgd      Actual (Average) Flow – 1.46mgd

**4. Mass DEP has information about your plant's backup power. Please confirm or correct the following information:**

a. In the case of an emergency does your facility own backup power?

Yes (a 750KW emergency generator and a 450KW emergency generator)

- b. If yes, how long can the backup generator operate without obtaining additional fuel?

Days

- c. Approximately what percentage of plant operation will be able to function during this time?

100 %

**5. Is your facility subject to rainfall induced flow?**

Yes

- a. If No, how much does the increase in flow exceed capacity:

0-10%

**6. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

No

**7. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes

- a. If yes, what type of protective or precautionary structures?

Weather tight gasketed doors

**8. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

**Wastewater Treatment Facility Flood Vulnerability Survey**

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** Robert J. Tina

**Title:** Director of Operations WWTP

**33. What are your responsibilities at the facility?**

Oversee the contractor operations and maintenance of the facility and pump stations

**34. Does your wastewater treatment facility have any equalization basins?**

Yes  No

**35. What are your facility's design flow and actual flow?**

25.8 MGD Design Flow 22 MGD Actual (Average) Flow

**36. Mass DEP has information about your plant's backup power. Please confirm or correct the following information:**

**a. In the case of an emergency does your facility own backup power?**

Yes  No (DEP data: Yes)

**i. If yes, how long can the backup generator operate without obtaining additional fuel?**

10 Days Hours \_\_\_\_ (DEP data: 10 Days)

**j. Approximately what percentage of plant operation will be able to function during this time?**

100 % (DEP data: 100%)

**37. Is your facility subject to rainfall induced flow?**

Yes No

a. If Yes, how much does the increase in flow exceed capacity:

0-10%  11-50%  50-100%  >100%

**38. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

(DEP data: Yes)

- See number 8 below -

**39. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

e. If yes, what type of protective or precautionary structures?

The WWTP has a plant bypass system (*which has never been utilized*) and the availability of an addition outfall (002) which is utilized only during excessive flows (storm events).

**40. Any additional comments or information regarding flood vulnerability?**

The WWTP itself did not experience any flooding (due to a storm event) that made plant operations inaccessible however, on May 18, 2006 during a significant rain event, the Washington Street Pump Station flooded and was inaccessible.

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## Manchester (with EPA)

### Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at MassDEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

Responders' name: John Sibbalds

Title: Chief Operator

1. What are your responsibilities at the facility?

Chief Plant Operator

2. Does your wastewater treatment facility have any equalization basins?

Yes  No

3. What are your facility's design flow and actual flow?

1.2 MGD Design Flow 0.42 MGD Actual (Average) Flow 5.2 MGD INSTANTANEOUS

4. Mass DEP has information about your plant's backup power. Please confirm or correct the following information:

- a. In the case of an emergency does your facility own backup power?

Yes  No (DEP data: Yes)

- a. If yes, how long can the backup generator operate without obtaining additional fuel?

1 Days 6 Hours (DEP data: 30 <sup>Hours</sup> Days)

b. Approximately what percentage of plant operation will be able to function during this time?

100 % (DEP data: 100%)

5. Is your facility subject to rainfall induced flow?

Yes  No

a. If No, how much does the increase in flow exceed capacity?

DEPENDS ON AMOUNT OF RAINFALL

0-10%  11-50%  50-100%  >100%

6. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?

Yes  No (DEP data: No)

a. If yes, please describe:

7. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)

Yes  No

a. If yes, what type of protective or precautionary structures?

8. Any additional comments or information regarding flood vulnerability?

**New Bedford (with EPA)**

**Wastewater Treatment Facility Flood Vulnerability Survey**

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** James Ricci

**Title:** Superintendent of Water

**41. What are your responsibilities at the facility? Oversee the City's O&M contractor, Veolia Water, capital improvement planning, permitting.**

**42. Does your wastewater treatment facility have any equalization basins?**

Yes  No

**43. What are your facility's design flow and actual flow?**

30 MGD Average Daily Design Flow      21.5MGD Actual (Average) Flow

75 MGD Maximum Daily Flow

**44. Mass DEP has information about your plant's backup power. Please confirm or correct the following information:**

**a. In the case of an emergency does your facility own backup power?**

Yes  No      (DEP data: Yes )

**k. If yes, how long can the backup generator operate without obtaining additional fuel?**

**Our generators are fueled by natural gas thus can operate for an unlimited time barring a disruption in the gas supply**

Days  Hours      (DEP data: None)

**l. Approximately what percentage of plant operation will be able to function during this time?**

100 %

(DEP data: 100% )

**45. Is your facility subject to rainfall induced flow?**

Yes  No

**a. If yes, how much does the increase in flow exceed capacity:**

0-10%  11-50%  50-100%  >100%

**46. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

(DEP data: No )

**a. If yes, please describe:**

**47. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No The facility was built at an elevation to withstand projected flooding for a 100 year storm. To achieve the necessary elevation, portions of the site were built up. The southern portion of the elevated area is protected by rip rap.

**f. If yes, what type of protective or precautionary structures?**

**48. Any additional comments or information regarding flood vulnerability?**

The facility is designed to treat a maximum flow of 75MGD. Should the flow rate reach this point, a sluice gate lowers regulating the flow into the facility. Excess flow would then back up into the collection system. The excess collection flow would then be discharged through CSO's located throughout the system.

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!



## Oak Bluffs (with EPA)

### Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis ([NDupuis@state.ma.us](mailto:NDupuis@state.ma.us)) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** Jim Monteith

**Title:** Acting Facilities Manager

1. **What are your responsibilities at the facility?** Acting facilities manager and chief operator

2. **Does your wastewater treatment facility have any equalization basins?**

Yes  No

3. **What are your facility's design flow and actual flow?**

330,000 GPD  Design Flow  summer seasonal average 150,000 GPD  Actual (Average)  
Flow

4. **Mass DEP has information about your plant's backup power. Please confirm or correct the following information:**

1. **In the case of an emergency does your facility own backup power?**

Yes  No (DEP data: Yes )

1. **If yes, how long can the backup generator operate without obtaining additional fuel?**

5 Days  Hours (DEP data: 5 Days)

2. **Approximately what percentage of plant operation will be able to function during this time?**

100 % (DEP data: 100% )

5. **Is your facility subject to rainfall induced flow?**

Yes  No

1. **If yes, how much does the increase in flow exceed capacity:**

0-10%  11-50%  50-100%  >100%

6. **Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

(DEP data: No )

**1. If yes, please describe:**

**7. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

**1. If yes, what type of protective or precautionary structures?**

**8. Any additional comments or information regarding flood vulnerability?**

We have three wet well pump stations that would be vulnerable in the case of hurricane storm surge.

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

**Plymouth (with EPA)**

**Wastewater Treatment Facility Flood Vulnerability Survey**

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at MassDEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** Shane McCauley / Gary Frizzle  
**Title:** Project Manager / Town Wastewater Manager

**1. What are your responsibilities at the facility?**

Management of WWTP & Collection System

**2. Does your wastewater treatment facility have any equalization basins?**

Yes  No

**3. What are your facility's design flow and actual flow?**

3.0<sup>MGD</sup> Design Flow 1.5<sup>MGD</sup> Actual (Average) Flow Peak 9.1 MGD

**4. Mass DEP has information about your plant's backup power. Please confirm or correct the following information:**

**a. In the case of an emergency does your facility own backup power?**

Yes  No

(DEP data: Yes)

**a. If yes, how long can the backup generator operate without obtaining additional fuel?**

14 Days  Hours

(DEP data: 14 Days)

**b. Approximately what percentage of plant operation will be able to function during this time?**

100 %

(DEP data: 100%)

**5. Is your facility subject to rainfall induced flow?**

Yes  No

a. If No, how much does the increase in flow exceed capacity:

0-10%  11-50%  50-100%  >100%

6. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?

Yes  No

(DEP data: No)

a. If yes, please describe:

7. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)

Yes  No

a. If yes, what type of protective or precautionary structures?

8. Any additional comments or information regarding flood vulnerability?

Water Street Headworks + Main Facility Pump Station is located adjacent to Plymouth Harbor, potentially subject to ocean surge.

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

Salisbury (with EPA)

Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

Instructions: Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

Responders' name: \_\_Jeff Ingalls\_\_\_\_\_

Title: \_\_Chief Operator\_\_\_\_\_

49. What are your responsibilities at the facility?

Everything

50. Does your wastewater treatment facility have any equalization basins?

\_\_ Yes \_X\_ No

51. What are your facility's design flow and actual flow?

\_\_1.3\_\_ Design Flow \_\_0.75\_\_ Actual (Average) Flow

52. Mass DEP has information about your plant's backup power. Please confirm or correct the following information:

a. In the case of an emergency does your facility own backup power?

\_X\_ Yes \_\_ No (DEP data: Yes )

m. If yes, how long can the backup generator operate without obtaining additional fuel?

\_\_3\_ Days \_\_ Hours (DEP data: 3 Days)

n. Approximately what percentage of plant operation will be able to function during this time?

\_\_100\_\_ % (DEP data: 100% )

53. Is your facility subject to rainfall induced flow?

Yes  No

a. If yes, how much does the increase in flow exceed capacity:

0-10%  11-50%  50-100%  >100%

**54. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

(DEP data: Yes)

a. If yes, please describe:

**55. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

g. If yes, what type of protective or precautionary structures?

**56. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

Scituate (with EPA)

Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

Instructions: Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

Responders' name: Bob Rowland

Title: Scituate Sewer Divisor-DPW, Supervisor

57. What are your responsibilities at the facility?

I am in responsible charge of both the WWTP and the sanitary collection system.

58. Does your wastewater treatment facility have any equalization basins?

\_\_ Yes X No

59. What are your facility's design flow and actual flow?

1.6 MGD Design Flow 1.067 MGD Actual (Average) Flow

60. Mass DEP has information about your plant's backup power. Please confirm or correct the following information:

a. In the case of an emergency does your facility own backup power?

\_\_ Yes \_\_ XX (DEP data: Yes)

o. If yes, how long can the backup generator operate without obtaining additional fuel?

1 Days 12 Hours (DEP data: 1.5 Days)

p. Approximately what percentage of plant operation will be able to function during this time?

100 % (DEP data: 100%)

61. Is your facility subject to rainfall induced flow?

Yes  XX

a. If yes, how much does the increase in flow exceed capacity:

0-10%  11-50%  50-100%  >100%

**62. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

(DEP data: Yes)

a. If yes, please describe:

The Sand Hills Pump Station has been flooded in the past.

**63. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

XX  No

h. If yes, what type of protective or precautionary structures?

**64. Any additional comments or information regarding flood vulnerability?**

In Oct.2011 avg. power consumption was 197 kw/hr., our Em.Gen.Set. is 750 kw.

$197/750 = 26.3\%$  of load, fuel consumption at that rate would give the WWTP

5.1 days of fuel, not 1.56 days.

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!



## Falmouth

### Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17th, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19th, 2012 to follow up.)

**Responders' name:** Gerald C Potamis

**Title:** WW Supt

**1. What are your responsibilities at the facility?**

I supervise the Chief operator who is licensed by Mass

**2. Does your wastewater treatment facility have any equalization basins?**

No

**3. What are your facility's design flow and actual flow?**

1.2 mgd Design Flow 0.5mgd Actual (Average) Flow

**4. In the case of an emergency does your facility have backup power?**

Yes

**a. If yes, how long can the backup generator operate without obtaining additional fuel?**

We can run continuously since we have ability to refuel

**b. What percentage of plant operation will be able to function during this time?**

100%

**5. Is your facility subject to rainfall induced flow?**

Yes

**a. If yes, how much does the increase in flow exceed capacity:**

0-10%  11-50%  51-100%  >100%

**6. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

No

**a. If yes, please describe:**

**7. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

No Not needed

**a. If yes, what type of protective or precautionary structures?**

**8. Any additional comments or information regarding flood vulnerability?**

All are pump stations have day tanks The WWTP is at a high elevation and not subject to flooding

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## Kingston

### Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** Kenneth P. Vandal

**Title:** Superintendent/ Chief Operator

**65. What are your responsibilities at the facility?**

**Oversee the operations and maintenance of the Treatment Facility and collection system including 15 pump stations.**

**66. Does your wastewater treatment facility have any equalization basins?**

Yes  No

**67. What are your facility's design flow and actual flow?**

375,000gpd Design Flow 320,000gpd Actual (Average) Flow

**68. In the case of an emergency does your facility have backup power?**

Yes  No

**q. If yes, how long can the backup generator operate without obtaining additional fuel?**

7 days \_\_\_\_\_ hours

**r. What percentage of plant operation will be able to function during this time?**

85 %

**69. Is your facility subject to rainfall induced flow?**

Yes  No

**a. If yes, how much does the increase in flow exceed capacity:**

0-10%    11-50%    51-100%    >100%

**70. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes    No

**a. If yes, please describe:**

**71. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes    No

**i. If yes, what type of protective or precautionary structures?**

**72. Any additional comments or information regarding flood vulnerability?**

The Treatment Facility is located at one of the highest points in Town, approximately 129 feet above sea level. The lowest pump station elevation is 10.5 feet above sea level.

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

**Moles Environmental Services, Inc.**

**Wastewater Treatment Facility Flood Vulnerability Survey**

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** \_Brian Moles\_\_\_\_\_

**Title:** Chief Operator \_\_\_\_\_

**73. What are your responsibilities at the facility? Day to day operations and maintenance**

**74. Does your wastewater treatment facility have any equalization basins?**

Yes       No

**75. What are your facility's design flow and actual flow?**

\_0.03 mgd\_\_\_\_\_ Design Flow \_0.006 mgd\_\_\_\_\_ Actual (Average) Flow

**76. In the case of an emergency does your facility have backup power?**

Yes     No

**s. If yes, how long can the backup generator operate without obtaining additional fuel?**

\_365\_\_ days      \_\_\_\_\_ hours

**t. What percentage of plant operation will be able to function during this time?**

100\_\_ %

**77. Is your facility subject to rainfall induced flow?**

Yes     No

**a. If Yes, how much does the increase in flow exceed capacity:**

0-10%  11-50%  51-100%  >100%

**78. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

**a. If yes, please describe:**

**79. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

**j. If yes, what type of protective or precautionary structures?**

**80. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## Nantucket (Surfside)

### Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** \_\_\_Robert Inglis\_\_\_\_\_

**Title:** \_\_\_\_\_Chief Operator\_\_\_\_\_

**81. What are your responsibilities at the facility?**

Day to day operation of facility

**82. Does your wastewater treatment facility have any equalization basins?**

\_\_\_ Yes  No

**83. What are your facility's design flow and actual flow?**

\_\_\_3.5 MGD\_\_\_ Design Flow \_\_\_1.3\_\_\_ Actual (Average) Flow

**84. In the case of an emergency does your facility have backup power?**

Yes \_\_\_ No

**u. If yes, how long can the backup generator operate without obtaining additional fuel?**

\_\_\_6\_\_\_ days \_\_\_\_\_ hours

**v. What percentage of plant operation will be able to function during this time?**

\_\_\_100\_\_\_ %

**85. Is your facility subject to rainfall induced flow?**

Yes \_\_\_ No

**a. If Yes, how much does the increase in flow exceed capacity:**

0-10%  11-50%  51-100%  >100% **Does not exceed**

**86. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

**a. If yes, please describe:**

**87. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

**k. If yes, what type of protective or precautionary structures?**

Bypass valve

**88. Any additional comments or information regarding flood vulnerability?**

Storm surges, 35 ft elevation above MSL

Coastal erosion is a more immediate threat than flooding

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!



## Automatic Coin Laundry

### Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** Andrew K. Rogers III

**Title:** Owner

**89. What are your responsibilities at the facility?**

Duties required to keep system running.

**90. Does your wastewater treatment facility have any equalization basins?**

Yes  No

**91. What are your facility's design flow and actual flow?**

20,000 Design Flow 9,700 Actual (Average) Flow

**92. In the case of an emergency does your facility have backup power?**

Yes  No

**w. If yes, how long can the backup generator operate without obtaining additional fuel?**

\_\_\_\_\_ days \_\_\_\_\_ hours

**x. What percentage of plant operation will be able to function during this time?**

\_\_\_\_\_ %

**93. Is your facility subject to rainfall induced flow?**

Yes  No

**a. If Yes, how much does the increase in flow exceed capacity:**

0-10%    11-50%    51-100%    >100%

**94. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

**a. If yes, please describe:**

**95. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

**l. If yes, what type of protective or precautionary structures?**

**96. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## Black Rock Golf Community

### Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** \_Peter Lewis \_\_\_\_\_

**Title:** \_Wastewater Operations Division Manager\_\_\_\_

**97. What are your responsibilities at the facility?**

**Operate & Maintain the WWTF**

**98. Does your wastewater treatment facility have any equalization basins?**

Yes  No

**99. What are your facility's design flow and actual flow?**

56,000gpd\_\_\_\_\_ Design Flow \_12-18,000gpd\_\_ Actual (Average) Flow

**100. In the case of an emergency does your facility have backup power?**

Yes  No

**y. If yes, how long can the backup generator operate without obtaining additional fuel? Piped in gas .....**

\_\_\_\_\_ days \_\_\_\_\_ hours

**z. What percentage of plant operation will be able to function during this time?**

\_100\_\_ %

**101. Is your facility subject to rainfall induced flow?**

Yes  No

**a. If No, how much does the increase in flow exceed capacity:**

0-10%  11-50%  51-100%  >100%

**102. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

**a. If yes, please describe:**

**103. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

**m. If yes, what type of protective or precautionary structures?**

**104. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## Linden Ponds at Hingham

### Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** \_\_James Gagliard\_\_\_\_\_

**Title:** \_\_Project Manager\_\_\_\_\_

**105. What are your responsibilities at the facility?**

Support technician (assist plant manager)

**106. Does your wastewater treatment facility have any equalization basins?**

Yes  No

**107. What are your facility's design flow and actual flow?**

333,000  Design Flow  100,000  Actual (Average) Flow

**108. In the case of an emergency does your facility have backup power?**

Yes  No

**aa. If yes, how long can the backup generator operate without obtaining additional fuel?**

2  days  hours

**bb. What percentage of plant operation will be able to function during this time?**

100  %

**109. Is your facility subject to rainfall induced flow?**

Yes  No

**a. If Yes, how much does the increase in flow exceed capacity:**

0-10%  11-50%  51-100%  >100%

**110. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

**a. If yes, please describe:**

**111. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

**n. If yes, what type of protective or precautionary structures?**

**112. Any additional comments or information regarding flood vulnerability?**

Don't believe that vulnerable to flooding.

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## Pilgrim Power Station

### Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** Jacob J. Scheffer

**Title:** Chemistry Supervisor

**113. What are your responsibilities at the facility?**

**Regulatory compliance**

**114. Does your wastewater treatment facility have any equalization basins?**

Yes     No    (Facility has an equalization tank)

**115. What are your facility's design flow and actual flow?**

37,500 gals/day Design Flow    4,000 gals/day Actual (Average) Flow (without rain water intrusion)

**116. In the case of an emergency does your facility have backup power?**

Yes     No

**cc. If yes, how long can the backup generator operate without obtaining additional fuel?**

\_\_\_\_\_ days    \_\_\_\_\_ 60 hours

**dd. What percentage of plant operation will be able to function during this time?**

100 %

**117. Is your facility subject to rainfall induced flow?**

Yes     No

**a. If yes, how much does the increase in flow exceed capacity:**

0-10%  11-50%  51-100%  >100%

**118. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

**a. If yes, please describe:**

**119. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

**o. If yes, what type of protective or precautionary structures?**

**120. Any additional comments or information regarding flood vulnerability?**

The facility is located on a hill about 90 ft above mean sea level. Generating Plant lift stations and septic tanks are at 23 ft above mean sea level.

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!



**Plymouth South High School**

**Wastewater Treatment Facility Flood Vulnerability Survey**

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** Shane McCannon

**Title:** Project Manager

**121. What are your responsibilities at the facility?**

**Project management and Operations/Maintenance**

**122. Does your wastewater treatment facility have any equalization basins?**

Yes  No

**123. What are your facility's design flow and actual flow?**

40000gpd Design Flow 15000gpd Actual (Average) Flow

**124. In the case of an emergency does your facility have backup power?**

Yes  No

**ee. If yes, how long can the backup generator operate without obtaining additional fuel?**

7 days        hours

**ff. What percentage of plant operation will be able to function during this time?**

100 %

**125. Is your facility subject to rainfall induced flow?**

Yes  No

**a. If Yes, how much does the increase in flow exceed capacity:**

0-10%  11-50%  51-100%  >100%

**126. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

**a. If yes, please describe:**

**127. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

**p. If yes, what type of protective or precautionary structures?**

**128. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## Spyglass Landing

### Wastewater Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** Kenneth Nugent

**Title:** Compliance Coordinator

**129. What are your responsibilities at the facility?**

I report the Monthly DMR sheets based on data provided by the Operator and testing laboratory.

**130. Does your wastewater treatment facility have any equalization basins?**

Yes      No

**131. What are your facility's design flow and actual flow?**

12,600 Design Flow 9,654 Actual (Average) Flow

**132. In the case of an emergency does your facility have backup power?**

Yes      No

**gg. If yes, how long can the backup generator operate without obtaining additional fuel?**

indefinite hours

**hh. What percentage of plant operation will be able to function during this time?**

100 %

**133. Is your facility subject to rainfall induced flow?**

Yes      No

**a. If Yes, how much does the increase in flow exceed capacity:**

0-10%  11-50%  51-100%  >100%

**134. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

**a. If yes, please describe:**

**135. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

**q. If yes, what type of protective or precautionary structures?**

**136. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

**White Cliffs Condo**

**Wastewater Treatment Facility Flood Vulnerability Survey**

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Responders' name:** David Boucher

**Title:** Northeast Regional Manager, Wastewater

**137. What are your responsibilities at the facility?** We operate the facility under contract for the permittee. We maintain all equipment and respond to alarm calls as needed.

**138. Does your wastewater treatment facility have any equalization basins?**

Yes  No

**139. What are your facility's design flow and actual flow?**

**0.08MGD** Design Flow **0.035MGD** Actual (Average) Flow

**140. In the case of an emergency does your facility have backup power?**

Yes  No

**ii. If yes, how long can the backup generator operate without obtaining additional fuel?**

**2** days \_\_\_\_\_ hours

**jj. What percentage of plant operation will be able to function during this time?**

**100** %

**141. Is your facility subject to rainfall induced flow?**

Yes  No

**a. If No, how much does the increase in flow exceed capacity:**

0-10%  11-50%  51-100%  >100%

**142. Has the facility suffered from any past flooding damage that may have made the plant operations inaccessible?**

Yes  No

**a. If yes, please describe:**

**143. Does the facility include any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

**r. If yes, what type of protective or precautionary structures?**

**144. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

# Drinking Water Facility Surveys

## Cambridge Water Department

### Drinking Water Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Respondent's Name:** \_Timothy MacDonald\_\_\_\_\_

**Title:** Director of Water Operations\_\_\_\_\_

**1. What are your responsibilities at the facility?**

Primary Operator, responsible for Plant, Lab and Watershed

**2. Which of the following best describes your treatment processes?**

Chemical addition only

Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)

Direct filtration

Membrane Filtration

**3. What is the elevation of the bottom of your finished water storage tank(s)?**

150.0\_\_\_\_\_ feet above Mean Sea Level (U.S. Geological Survey datum) – Payson Park finished water storage.

Plant Clearwell (lowest process tank at treatment facility): -4.84 feet

City of Cambridge datum, subtract 10.84 feet to elevations to adjust to National Geodetic Vertical Datum of 1929. 6 feet -10.84 feet = -4.84 feet

**4. In case of emergency, does your facility own backup power onsite?**

Yes  No

- a. **If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?**

\_\_\_\_\_ days    \_\_\_\_\_ hours

Natural gas, unlimited as long as supply is available

- b. **Approximately what percentage of plant operation will be able to function during this time?**

\_0\_ %

Only lighting and HVAC is powered, none of the process is power by the generator.

Two independent power feeds, 32 million gallons of finished water storage and MWRA supply backup all provide emergency supply options.

5. **Has the facility suffered from any past flooding damage?**

X\_\_ Yes    \_\_ No

- a. **If yes, please describe:**

Internal pipe failure.

No external flooding experienced for the existence of the water system.

6. **Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

\_\_ Yes    x\_\_ No

- a. **If yes, please list what types of protective or precautionary structures below:**

CWD manages the level of Fresh Pond to preclude flooding.

7. **Any additional comments or information regarding flood vulnerability?**

The City (Cambridge) has just initiated a Climate Change Vulnerability Assessment, the water system will be part of the assessment.

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!



Dartmouth Water Division

Drinking Water Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

Instructions: Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

Respondent's Name: \_\_Steven Sullivan\_\_\_\_\_

Title: \_\_\_\_\_Superintendent\_\_\_\_\_

1. What are your responsibilities at the facility?Operations

2. Which of the following best describes your treatment processes?

- \_\_ Chemical addition only
\_\_ Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)
\_X\_ Direct filtration
\_\_ Membrane Filtration

3. What is the elevation of the bottom of your finished water storage tank(s)?

\_\_\_112\_\_\_ feet above Mean Sea Level (U.S. Geological Survey datum)

4. In case of emergency, does your facility own backup power onsite?

X\_\_ Yes \_\_ No

a. If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?

\_\_\_30\_\_ days \_\_\_\_\_ hours

- b. Approximately what percentage of plant operation will be able to function during this time?**

  100   %

- 5. Has the facility suffered from any past flooding damage?**

   Yes   X   No

- a. If yes, please describe:**

- 6. Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

   Yes   X   No

- a. If yes, please list what types of protective or precautionary structures below:**

- 7. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## Edgartown Water Department

### Drinking Water Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Respondent's Name:** Fred R Domont

**Title:** Superintendent

**1. What are your responsibilities at the facility? Supervision of operators.**

**2. Which of the following best describes your treatment processes?**

Chemical addition only

Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)

Direct filtration

Membrane Filtration

**3. What is the elevation of the bottom of your finished water storage tank(s)?**

60 feet above Mean Sea Level (U.S. Geological Survey datum)

**4. In case of emergency, does your facility own backup power onsite?**

Yes  No

**a. If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?**

         days 15 to 20 hours

- b. Approximately what percentage of plant operation will be able to function during this time?**

100 %

- 5. Has the facility suffered from any past flooding damage?**

Yes  No

- a. If yes, please describe:**

- 6. Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No NA

- a. If yes, please list what types of protective or precautionary structures below:**

- 7. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## Mashpee Water District

### Drinking Water Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Respondent's Name:** \_\_Andrew Marks\_\_\_\_\_

**Title:** \_\_Operations manager\_\_\_\_\_

**1. What are your responsibilities at the facility?**

supervision

**2. Which of the following best describes your treatment processes?**

Chemical addition only

Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)

Direct filtration

Membrane Filtration

**3. What is the elevation of the bottom of your finished water storage tank(s)?**

\_\_\_105\_\_\_ feet above Mean Sea Level (U.S. Geological Survey datum)

**4. In case of emergency, does your facility own backup power onsite?**

Yes  No

**a. If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?**

\_\_\_14\_\_\_ days \_\_\_\_\_ hours

- b. Approximately what percentage of plant operation will be able to function during this time?**

  100   %

- 5. Has the facility suffered from any past flooding damage?**

   Yes   X   No

- a. If yes, please describe:**

- 6. Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

   Yes   X   No

- a. If yes, please list what types of protective or precautionary structures below:**

- 7. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## Newburyport Water Department

### Drinking Water Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Respondent's Name:** \_\_\_\_\_ **Paul Colby**\_\_\_\_\_

**Title:** \_\_\_\_\_ **Superintendent**\_\_\_\_\_

**1. What are your responsibilities at the facility?**

*Oversee staff and operation of water treatment facilities*

**2. Which of the following best describes your treatment processes?**

Chemical addition only

Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)

Direct filtration

Membrane Filtration

**3. What is the elevation of the bottom of your finished water storage tank(s)?**

**88' & 101'** \_\_\_\_\_ feet above Mean Sea Level (U.S. Geological Survey datum)

**4. In case of emergency, does your facility own backup power onsite?**

Yes  No

**a. If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?**

\_\_\_\_\_ **3** \_\_\_\_\_ days \_\_\_\_\_ hours

- b. Approximately what percentage of plant operation will be able to function during this time?**

100 %

- 5. Has the facility suffered from any past flooding damage?**

Yes  No

- a. If yes, please describe:**

- 6. Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

- a. If yes, please list what types of protective or precautionary structures below:**

- 7. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!



## Norwell Water Department

### Drinking Water Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Respondent's Name:** \_John R McInnis\_\_\_\_\_

**Title:** \_Water Superintendent\_\_\_\_\_

**1. What are your responsibilities at the facility?**

Management of public water supply; both treatment and distribution.

**2. Which of the following best describes your treatment processes?**

Chemical addition only

Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)

Direct filtration

Membrane Filtration

**3. What is the elevation of the bottom of your finished water storage tank(s)?**

\_200\_\_\_\_\_ feet above Mean Sea Level (U.S. Geological Survey datum)

**4. In case of emergency, does your facility own backup power onsite?**

Yes  No

**a. If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?**

\_\_\_2\_\_\_ days \_\_\_\_\_ hours

- b. Approximately what percentage of plant operation will be able to function during this time?**

100 %

- 5. Has the facility suffered from any past flooding damage?**

Yes  No

- a. If yes, please describe:**

- 6. Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

- a. If yes, please list what types of protective or precautionary structures below:**

- 7. Any additional comments or information regarding flood vulnerability?**

No flood protection is necessary as the lowest elevation of any system facility is 68 ft. ABS

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## Pleasant Water

### Drinking Water Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Respondent's Name:** \_\_\_\_\_ Liz Sorrell \_\_\_\_\_

**Title:** \_\_\_\_\_ President of the Board of Directors for Pleasant Water, Inc. \_\_\_\_\_

**1. What are your responsibilities at the facility?**

As president of the board, I convene the board to set rates and make policy decisions for the operation of Pleasant Water, Inc.

**2. Which of the following best describes your treatment processes?**

Chemical addition only

Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)

Direct filtration

Membrane Filtration

**3. What is the elevation of the bottom of your finished water storage tank(s)?**

\_\_\_\_\_12 feet\_\_\_\_\_ feet above Mean Sea Level (U.S. Geological Survey datum)

**4. In case of emergency, does your facility own backup power onsite?**

x\_ Yes  No

**a. If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?**

\_\_\_6\_\_\_ days \_\_\_\_\_ hours

- b. Approximately what percentage of plant operation will be able to function during this time?**

  100   %

- 5. Has the facility suffered from any past flooding damage?**

   Yes   x   No

- a. If yes, please describe:**

- 6. Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

  x   Yes    No

- a. If yes, please list what types of protective or precautionary structures below:**

Loagy Bay is 100 feet from the pump house. There is a 12 ft sea wall there.

- 7. Any additional comments or information regarding flood vulnerability?**

In thirty years, there has not been a breach of the sea wall.

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## Rockport Water Department

### Drinking Water Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Respondent's Name:** \_\_Chris Martin\_\_\_\_\_

**Title:** \_\_Water Plant supervisor\_\_\_\_\_

**1. What are your responsibilities at the facility?**

Oversee plant operations and maintenance

**2. Which of the following best describes your treatment processes?**

Chemical addition only

Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)

Direct filtration

Membrane Filtration

**3. What is the elevation of the bottom of your finished water storage tank(s)?**

\_\_\_10\_\_\_ feet above Mean Sea Level (U.S. Geological Survey datum)

**4. In case of emergency, does your facility own backup power onsite?**

Yes  No

**a. If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?**

\_\_\_\_\_ days    \_\_8\_\_ hours

- b. Approximately what percentage of plant operation will be able to function during this time?**

  50   % (one plant of the two)

- 5. Has the facility suffered from any past flooding damage?**

   Yes   X   No

- a. If yes, please describe:**

- 6. Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

   Yes   X   No

- a. If yes, please list what types of protective or precautionary structures below:**

- 7. Any additional comments or information regarding flood vulnerability?**

Typically outages in the winter.

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## Westport Senior Village

### Drinking Water Treatment Facility Flood Vulnerability Survey

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Respondent's Name:** \_\_\_Michael Bizsko\_\_\_\_\_

**Title:** \_\_\_VP\_\_\_\_\_

**1. What are your responsibilities at the facility?**

Administrative

**2. Which of the following best describes your treatment processes?**

\_\_\_ Chemical addition only

\_\_\_ Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)

\_X\_ Direct filtration

\_\_\_ Membrane Filtration

**3. What is the elevation of the bottom of your finished water storage tank(s)?**

\_\_\_94\_\_\_ feet above Mean Sea Level (U.S. Geological Survey datum)

**4. In case of emergency, does your facility own backup power onsite?**

\_X\_ Yes \_\_\_ No

**a. If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?**

\_\_\_\_\_ days      \_\_\_\_\_ hours

continuous

- b. Approximately what percentage of plant operation will be able to function during this time?**

  100   %

- 5. Has the facility suffered from any past flooding damage?**

   Yes   X   No

- a. If yes, please describe:**

- 6. Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

  X   Yes    No

- a. If yes, please list what types of protective or precautionary structures below:**

Pumps tied into floats, alarm, generator.

- 7. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!



**Drinking Water Treatment Facility Flood Vulnerability Survey**

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Respondent's Name:** Anthony Baker\_\_\_\_\_

**Title:** \_operator\_\_\_\_\_

**1. What are your responsibilities at the facility? Operation of the water system**

**2. Which of the following best describes your treatment processes?**

Chemical addition only

Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)

Direct filtration

Membrane Filtration

**3. What is the elevation of the bottom of your finished water storage tank(s)?**

116\_\_\_\_\_ feet above Mean Sea Level (U.S. Geological Survey datum)

**4. In case of emergency, does your facility own backup power onsite?**

Yes  No

**a. If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?**

\_\_\_5\_\_\_ days \_\_\_\_\_ hours

- b. Approximately what percentage of plant operation will be able to function during this time?**

  100   %

- 5. Has the facility suffered from any past flooding damage?**

   Yes   X   No

- a. If yes, please describe:**

- 6. Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

   Yes   X   No

- a. If yes, please list what types of protective or precautionary structures below:**

- 7. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

**Drinking Water Treatment Facility Flood Vulnerability Survey**

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Respondent's Name:** \_\_Gary Krum\_\_\_\_\_

**Title:** \_\_Manager\_\_\_\_\_

**1. What are your responsibilities at the facility?**

Hire water treatment company

**2. Which of the following best describes your treatment processes?**

Chemical addition only

Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)

Direct filtration

Membrane Filtration

**3. What is the elevation of the bottom of your finished water storage tank(s)?**

\_\_50\_\_ feet above Mean Sea Level (U.S. Geological Survey datum)

**4. In case of emergency, does your facility own backup power onsite?**

Yes  No

**a. If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?**

\_\_\_\_\_ days      \_\_\_\_\_ hours

- b. Approximately what percentage of plant operation will be able to function during this time?**

\_\_\_\_\_ %

- 5. Has the facility suffered from any past flooding damage?**

Yes  No

- a. If yes, please describe:**

- 6. Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

- a. If yes, please list what types of protective or precautionary structures below:**

- 7. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

**The Baird Center**

**Drinking Water Treatment Facility Flood Vulnerability Survey**

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Respondent's Name:** Rob Stowe

**Title:** Maintenance Supervisor

**1. What are your responsibilities at the facility?**

Grounds, buildings

**2. Which of the following best describes your treatment processes?**

Chemical addition only

Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)

Direct filtration

Membrane Filtration

**3. What is the elevation of the bottom of your finished water storage tank(s)?**

70 feet above Mean Sea Level (U.S. Geological Survey datum)

**4. In case of emergency, does your facility own backup power onsite?**

Yes  No

**a. If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?**

14 days \_\_\_\_\_ hours

- b. Approximately what percentage of plant operation will be able to function during this time?**

  100   %

- 5. Has the facility suffered from any past flooding damage?**

   Yes   X   No

- a. If yes, please describe:**

- 6. Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

   Yes   X   No

- a. If yes, please list what types of protective or precautionary structures below:**

- 7. Any additional comments or information regarding flood vulnerability?**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

## New Testament Church

### Drinking Water Treatment Facility Flood Vulnerability Survey

Monday, September 17th, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19th, 2012 to follow up.)

**Respondent's Name: Allan K. Turner**

**Title: Deacon**

**1. What are your responsibilities at the facility?**

Deacon and Assistant Principal/Administrator

**2. Which of the following best describes your treatment processes? ION EXCHANGE**

Chemical addition only

Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)

Direct filtration

Membrane Filtration

**3. What is the elevation of the bottom of your finished water storage tank(s)?**

UNKNOWN – SMALL SYSTEM WITH PRESSURE TANK feet above Mean Sea Level (U.S. Geological Survey datum)

**4. In case of emergency, does your facility own backup power onsite?**

Yes  No

**a. If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?**

\_\_\_\_\_ days \_\_\_\_\_ hours

**b. Approximately what percentage of plant operation will be able to function during this time?**

%

**5. Has the facility suffered from any past flooding damage?**

Yes  No

**a. If yes, please describe:**

**6. Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

**a. If yes, please list what types of protective or precautionary structures below:**

**7. Any additional comments or information regarding flood vulnerability?**

**This is a very small system serving a church**

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!



**Plymouth South High School**

**Drinking Water Treatment Facility Flood Vulnerability Survey**

Monday, September 17<sup>th</sup>, 2012

**Instructions:** Please fill out the following survey questions to the best of your ability and return via email ASAP to Nicolas Dupuis (NDupuis@state.ma.us) at Mass DEP. (Note that a representative of the project will be contacting your facility by phone by Wednesday, September 19<sup>th</sup>, 2012 to follow up.)

**Respondent's Name:** Frank Silva Jr.

**Title:** Supervisor of Building and Grounds

**1. What are your responsibilities at the facility?**

*I am responsible for the sampling, and submitting all monthly reports*

**2. Which of the following best describes your treatment processes?**

Chemical addition only

Conventional filtration (includes conventional clarification/ sedimentation, up flow clarification, dissolved air floatation, or pulsator technology)

Direct filtration

Membrane Filtration

**3. What is the elevation of the bottom of your finished water storage tank(s)?**

N/A feet above Mean Sea Level (U.S. Geological Survey datum)

**4. In case of emergency, does your facility own backup power onsite?**

Yes  No

**a. If yes, how long can the backup generator (or other backup power source) operate without obtaining additional fuel?**

2 days \_\_\_\_\_ hours

- b. **Approximately what percentage of plant operation will be able to function during this time?**

100 %

5. **Has the facility suffered from any past flooding damage?**

Yes  No

- a. **If yes, please describe:**

6. **Does the facility currently have any protective or precautionary structures to minimize the impacts of flooding? (Examples include sea walls, dikes, bypass systems, etc.)**

Yes  No

- a. **If yes, please list what types of protective or precautionary structures below:**

7. **Any additional comments or information regarding flood vulnerability?**

None at this time

THANK YOU VERY MUCH FOR YOUR ASSISTANCE TO THIS PROJECT!

# APPENDIX C: RISK ASSESSMENT TOOL

Drinking Water Facilities vs. Risk Factors													
Community:	FEMA Flood Zone	Inundation Zone	Facility (Alerts)	Flooding (y/n)	Water source (SW, GW/UD, GW)	Treatment processes	Protective structures (y/n)	Onsite power (y/n)	Longevity of backup power	Processes that can run (%)	Member of Mass WARN (y/n)	Member of Mass storage tanks (feet)	SCORE
BARNSTABLE FIRE DISTRICT	0	0	13	Y	gw				0	0%	n	n	N/A
CAMBRIDGE WATER DEPARTMENT	500	1	4	Y	sw	conventional filtration	n	Y	continuous	50%	n	n	-4.94
DARTMOUTH WATER DIVISION	100	0	8	n	sw	direct filtration	n	Y	30	100%	n	n	112
EDGARTOWN WATER DEPARTMENT	100	3	2.3	n	gw	chemical addition	n	Y	0.833	100%	Y	Y	60
MASHPE WATER DISTRICT	0	0	10.7	n	gw/ud	conventional filtration	n	Y	14	100%	n	n	105
NEWBURYPORT WATER DEPARTMENT	0	3	3	n	sw	conventional filtration	n	Y	3	100%	n	n	88
PLEASANT WATER	0	0	15	n	gw	conventional filtration	Y	Y	6	100%	n	n	12
ROCKPORT WATER DEPT	0	0	28	n	sw	conventional filtration	n	Y	0.3300	50%	n	n	10
NORWELL WATER DEPARTMENT	100	0	1.7	n	gw	direct filtration	n	Y	2	100%	n	n	200
WESTPORT SENIOR VILLAGE	100	0	4.2	n	gw	direct filtration	n	Y	continuous	100%	n	n	94
Non-community:													
Non-community Transient:													
	FEMA Flood Zone	Inundation Zone	Facility (Alerts)	Flooding (y/n)	Water source (SW, GW/UD, GW)	Treatment processes	Protective structures (y/n)	Onsite power (y/n)	Longevity of backup power	Processes that can run (%)	Member of Mass WARN (y/n)	Member of Mass storage tanks (feet)	SCORE
CCNS SALT POND VISITOR CTR	0	0	10.8		gw						n	n	N/A
GIBSON COTTAGES	0	0	11		gw						n	n	N/A
MARITIC DRAGON RESTAURANT	0	0	8		gw						n	n	N/A
PINEWOODS CAMP INC.	0	0	21	n	gw	chemical addition	n	Y	5	100%	n	n	116
SEATOLLER				n	gw	conventional filtration	n	n	0	0%	n	n	50
Non-community Transient:													
	FEMA Flood Zone	Inundation Zone	Facility (Alerts)	Flooding (y/n)	Water source (SW, GW/UD, GW)	Treatment processes	Protective structures (y/n)	Onsite power (y/n)	Longevity of backup power	Processes that can run (%)	Member of Mass WARN (y/n)	Member of Mass storage tanks (feet)	SCORE
CAPABILITIES	0	0	10		gw						n	n	N/A
CCNS MARCONI AREA					gw						n	n	N/A
ISLAND CHILDREN'S SCHOOL					gw						n	n	N/A
PLYMOUTH SOUTH HIGH SCHOOL	0	0	60	n	gw	chemical addition	n	Y	2	100%	n	n	0
SACRED HEART EARLY CHILDHOOD CENTER					gw						n	n	N/A
STONES THROW CONDOS					gw						n	n	N/A
THE BARD CENTER	0	0	11.7	n	gw	chemical addition	n	Y	14	100%	n	n	70
THE NEW TESTAMENT CHURCH	0	0	20	n	gw	chemical addition	n	n	0	0%	n	n	0
WESTPORT ELEM. SCHOOL					gw						n	n	N/A



## **APPENDIX D: INDIVIDUAL FACILITY RESULT SHEET**

---

NOTE: In the following pages are each of the thirty-seven individual facility result sheets.



# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Cambridge Drinking Water Treatment Facility

**HIGH: 74.5/100**

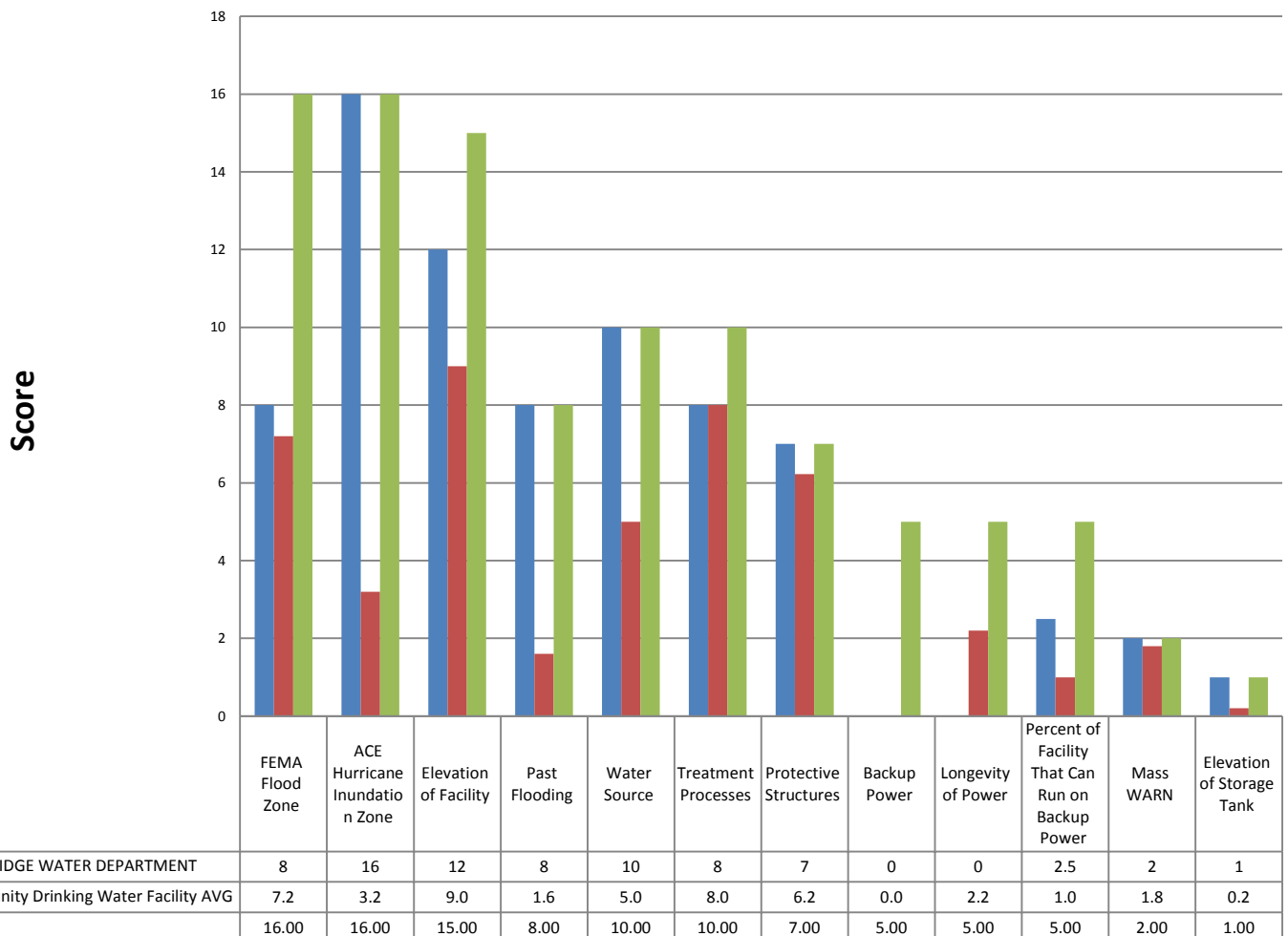
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal drinking water treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist drinking water treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

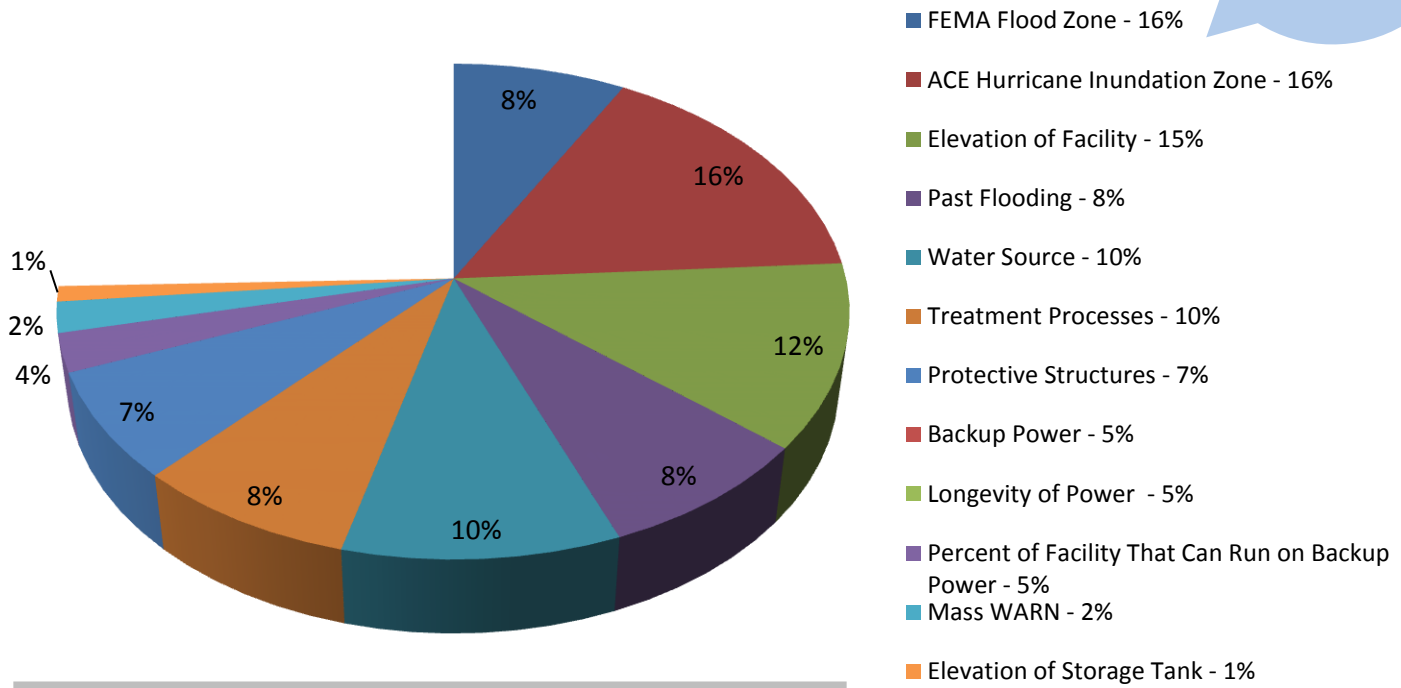
**Flood Risk Assessment - Cambridge Water Department**



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# CAMBRIDGE WATER DEPARTMENT

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Although your facility lays in the highest categories of the FEMA and ACE zones which make up a significant portion of your risk level, there are areas in some of the factors where proactive measures may be taken to mitigate the effects of flooding which would then lower your facility’s risk level:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Increase percent of facility that can run on backup power
- Create protective structures

### **For More Information:**

Paul Niman,  
[Paul.niman@state.ma.us](mailto:Paul.niman@state.ma.us)  
 617-556-1166



# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at Dartmouth Water Division Treatment Facility

**MEDIUM: 57/100**

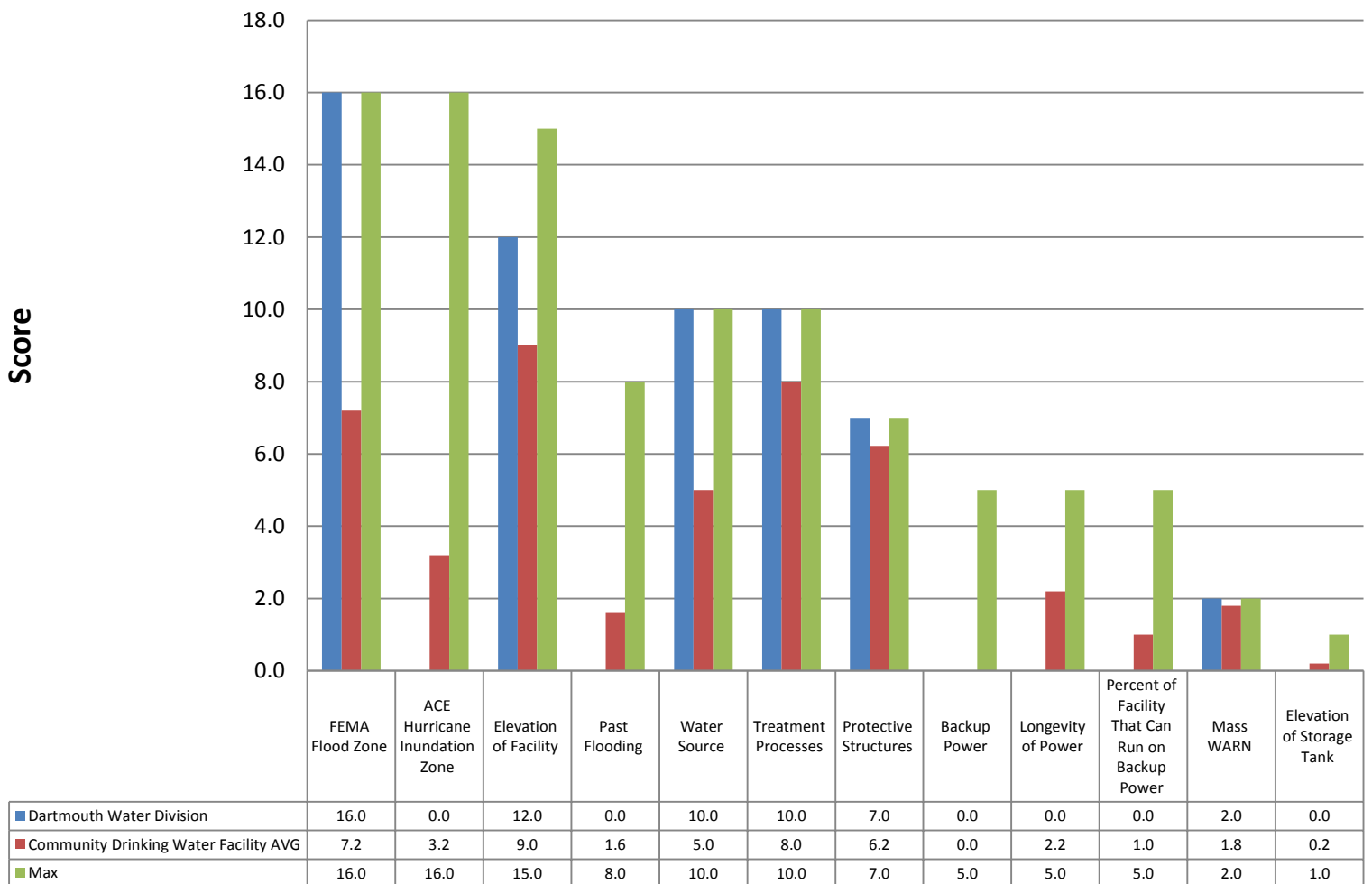
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal drinking water treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist drinking water treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

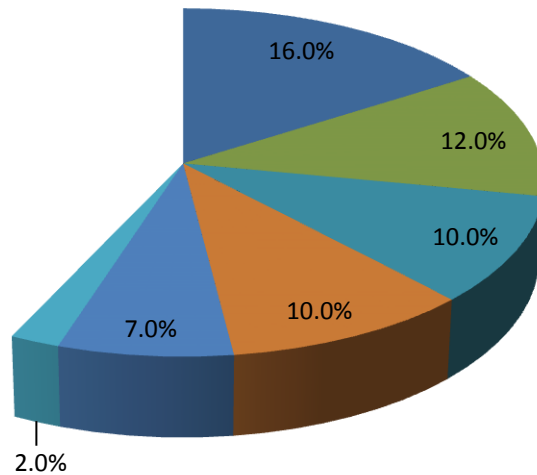
## Flood Risk Assessment – Dartmouth Water Division



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Dartmouth Water Division

*Maximum Possible Percentage per Factor*



- FEMA Flood Zone - 16%
- ACE Hurricane Inundation Zone - 16%
- Elevation of Facility - 15%
- Past Flooding - 8%
- Water Source - 10%
- Treatment Processes - 10%
- Protective Structures - 7%
- Backup Power - 5%
- Longevity of Power - 5%
- Percent of Facility That Can Run on Backup Power - 5%
- Mass WARN - 2%
- Elevation of Storage Tank - 1%

FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## **Resources and Assistance Available for Flood Resiliency Measures:**

Your facility was found to be in a FEMA Flood Zone, but not an ACE Hurricane Inundation Zone. Your facility was found to be at a medium risk for flooding. Although your facility only ranked at a medium level, there are still actions that may be taken to decrease the facility's risk of flooding.

## **Potential to decrease Risk Level:**

- Become a member of Mass WARN
- Install Protective Structures

## **For More Information:**

Paul Niman,  
[Paul.niman@state.ma.us](mailto:Paul.niman@state.ma.us)  
 617-556-1166

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at Edgartown Water Department Treatment Facility

**MEDIUM: 49/100**

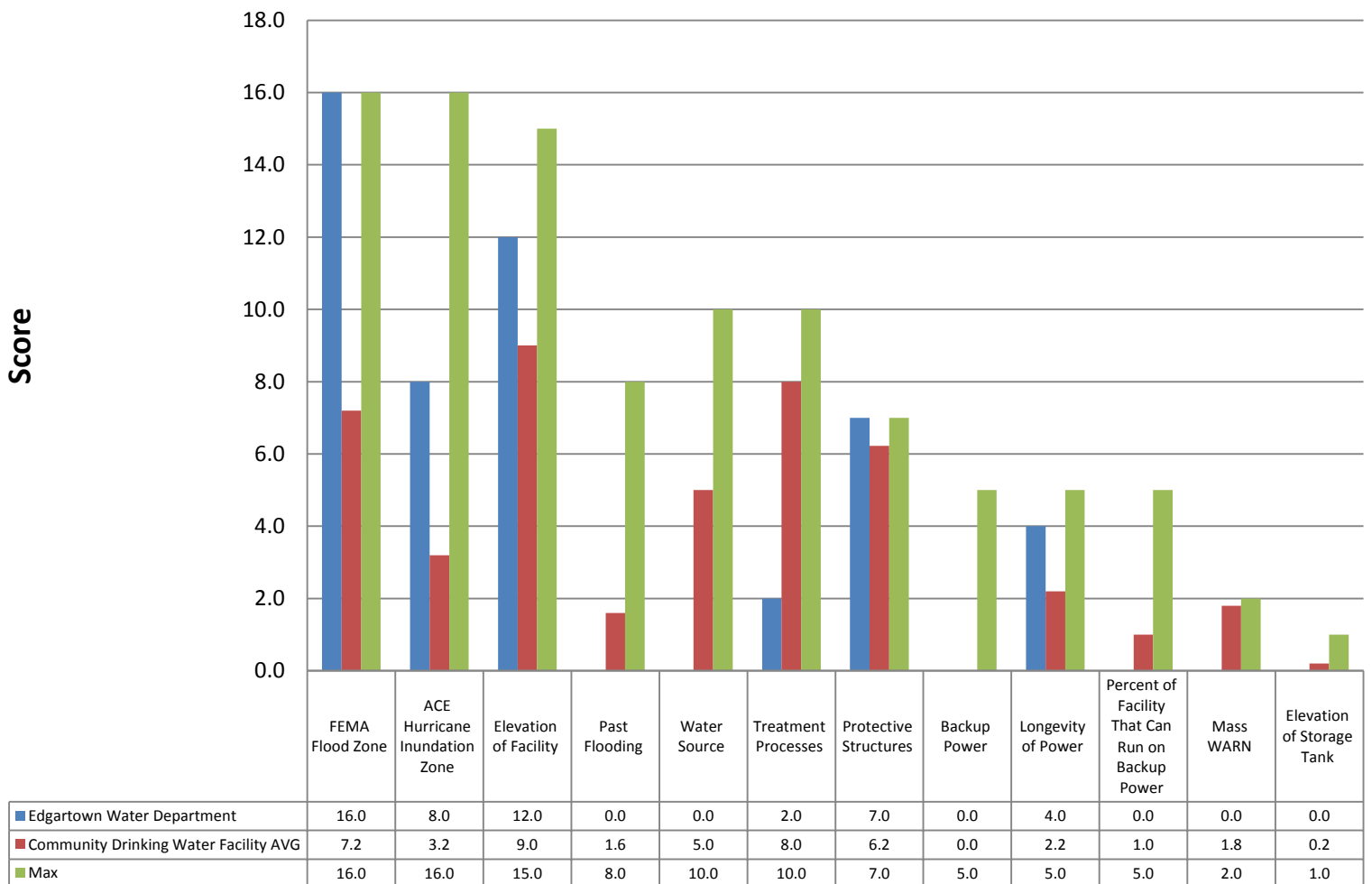
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal drinking water treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist drinking water treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

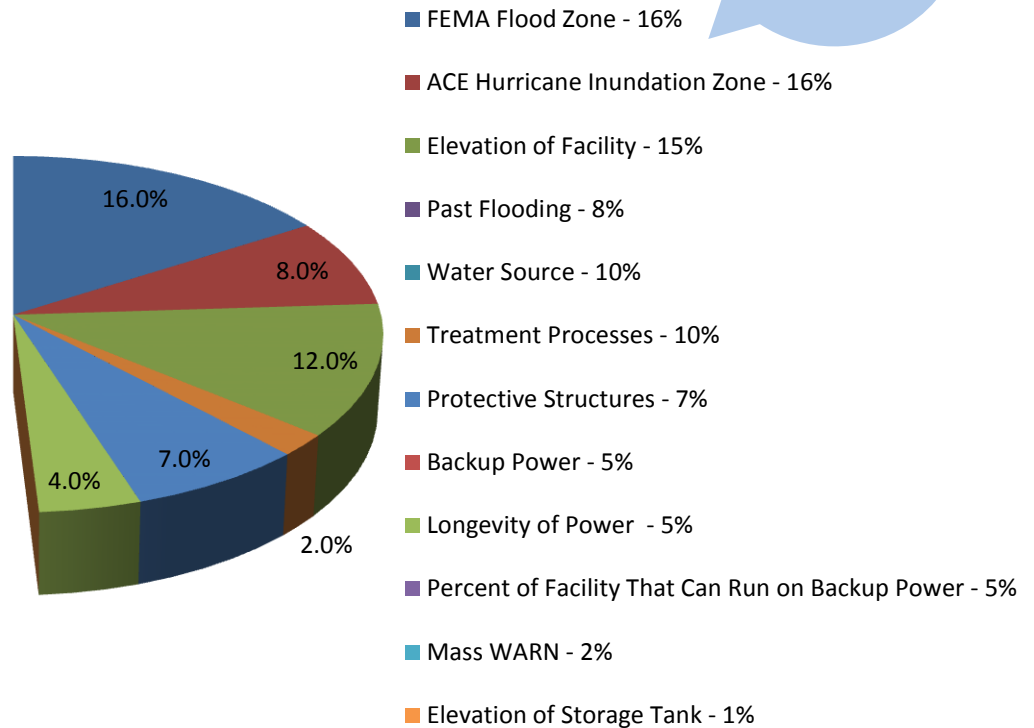
## Flood Risk Assessment – Edgartown Water Department



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Edgartown Water Department

Maximum Possible Percentage per Factor



FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## **Resources and Assistance Available for Flood Resiliency Measures:**

Your facility was found to be in a FEMA Flood Zone, and ACE Hurricane Inundation Zone which make up a significant portion of your risk level. Although your facility only ranked at a medium level, there are still actions that may be taken to decrease the facility's risk of flooding.

### **Potential to decrease Risk Level:**

- Install Protective Structures
- Increase longevity of backup power

### **For More Information:**

Paul Niman,  
[Paul.niman@state.ma.us](mailto:Paul.niman@state.ma.us)  
 617-556-1166

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at Mashpee Water District Treatment Facility

**MEDIUM: 36/100**

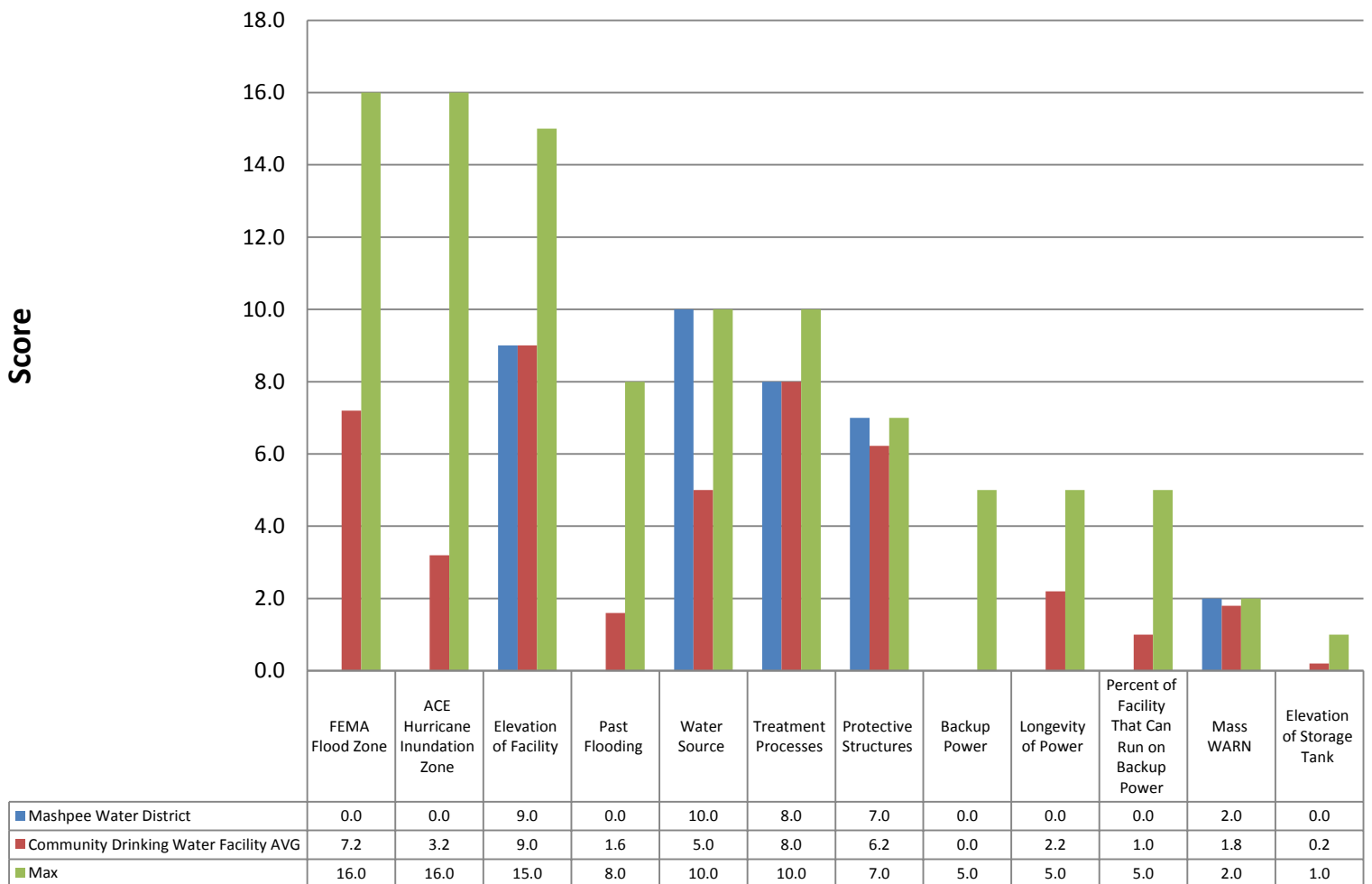
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal drinking water treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist drinking water treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

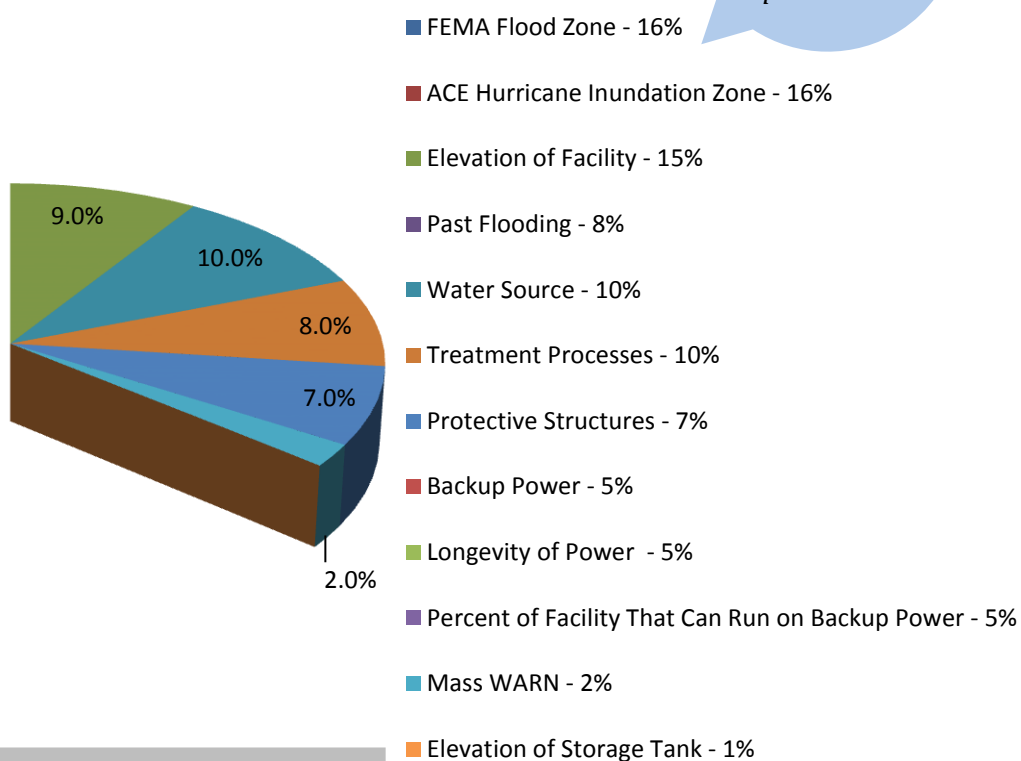
## Flood Risk Assessment – Mashpee Water District



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Mashpee Water District

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## **Resources and Assistance Available for Flood Resiliency Measures:**

Your facility was not found to be in any FEMA Flood Zone, or ACE Hurricane Inundation Zones, which are the highest weighted factors. Although your facility only ranked at a medium level, there are still actions that may be taken to decrease the facility’s risk of flooding.

### **Potential to decrease Risk Level:**

- Become a member of Mass WARN
- Install Protective Structures

### **For More Information:**

Paul Niman,  
[Paul.niman@state.ma.us](mailto:Paul.niman@state.ma.us)  
 617-556-1166

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at Newburyport Water Department Treatment Facility

**MEDIUM: 50/100**

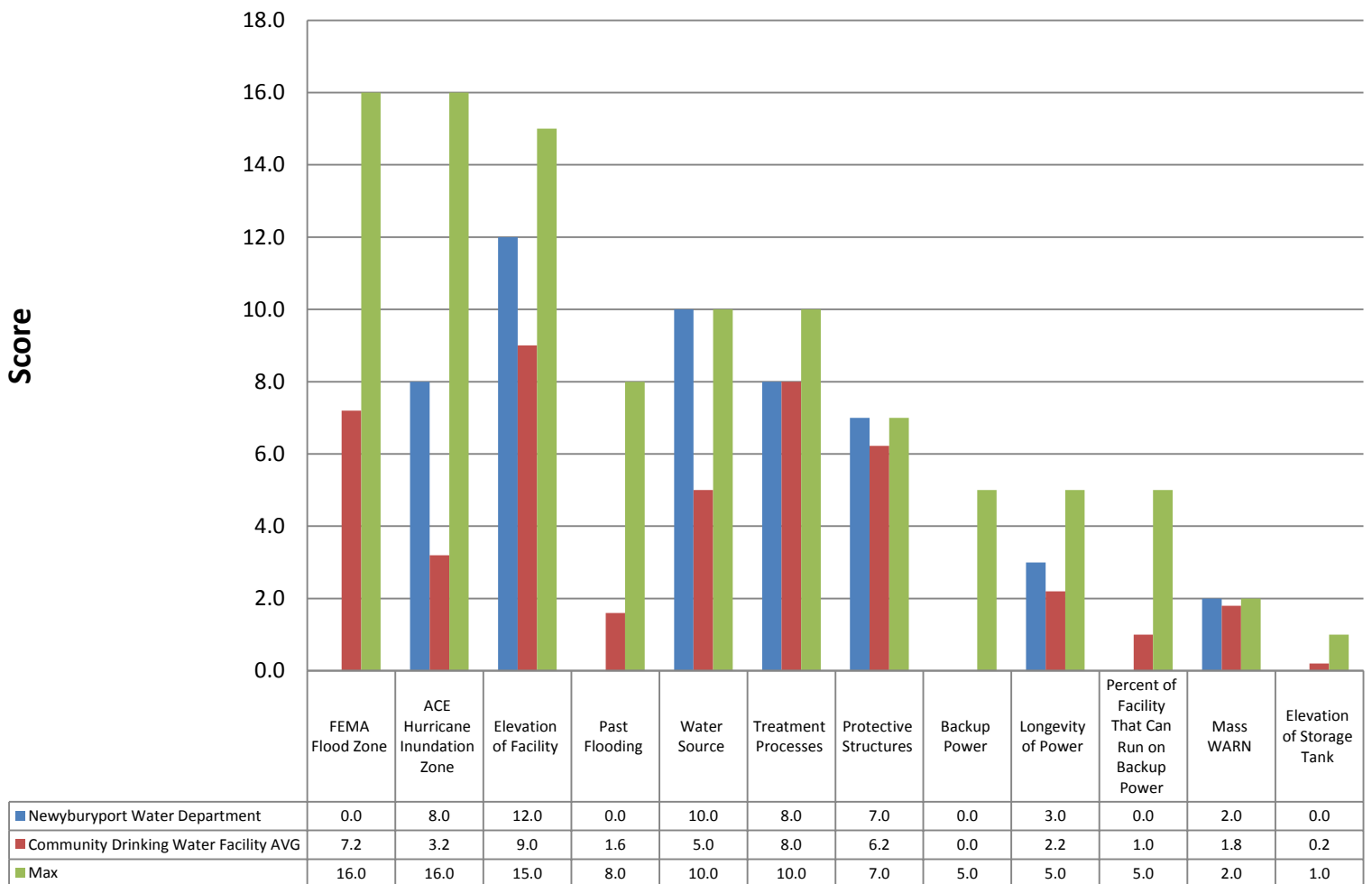
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal drinking water treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist drinking water treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

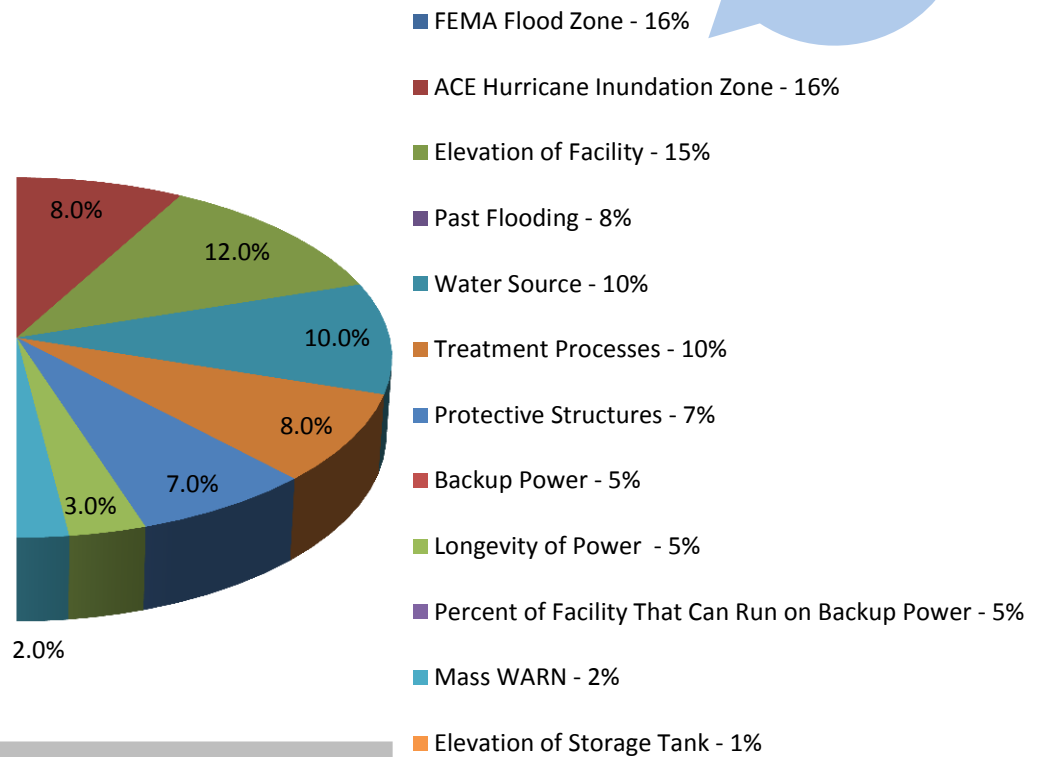
## Flood Risk Assessment – Newburyport Water Department



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Newburyport Water Department

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## **Resources and Assistance Available for Flood Resiliency Measures:**

Your facility was not found to be in any FEMA Flood Zone, and ranked in a low category when it came to observing the ACE categories. However your facility did rank at a medium level for flooding because there are some areas where you may improve:

### **Potential to decrease Risk Level:**

- Become a member of Mass WARN
- Install Protective Structures
- Increase longevity of backup power

### **For More Information:**

Paul Niman,  
[Paul.niman@state.ma.us](mailto:Paul.niman@state.ma.us)  
 617-556-1166



# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

**Flood Risk Score at Norwell Water Department Treatment Facility**

**MEDIUM: 48/100**

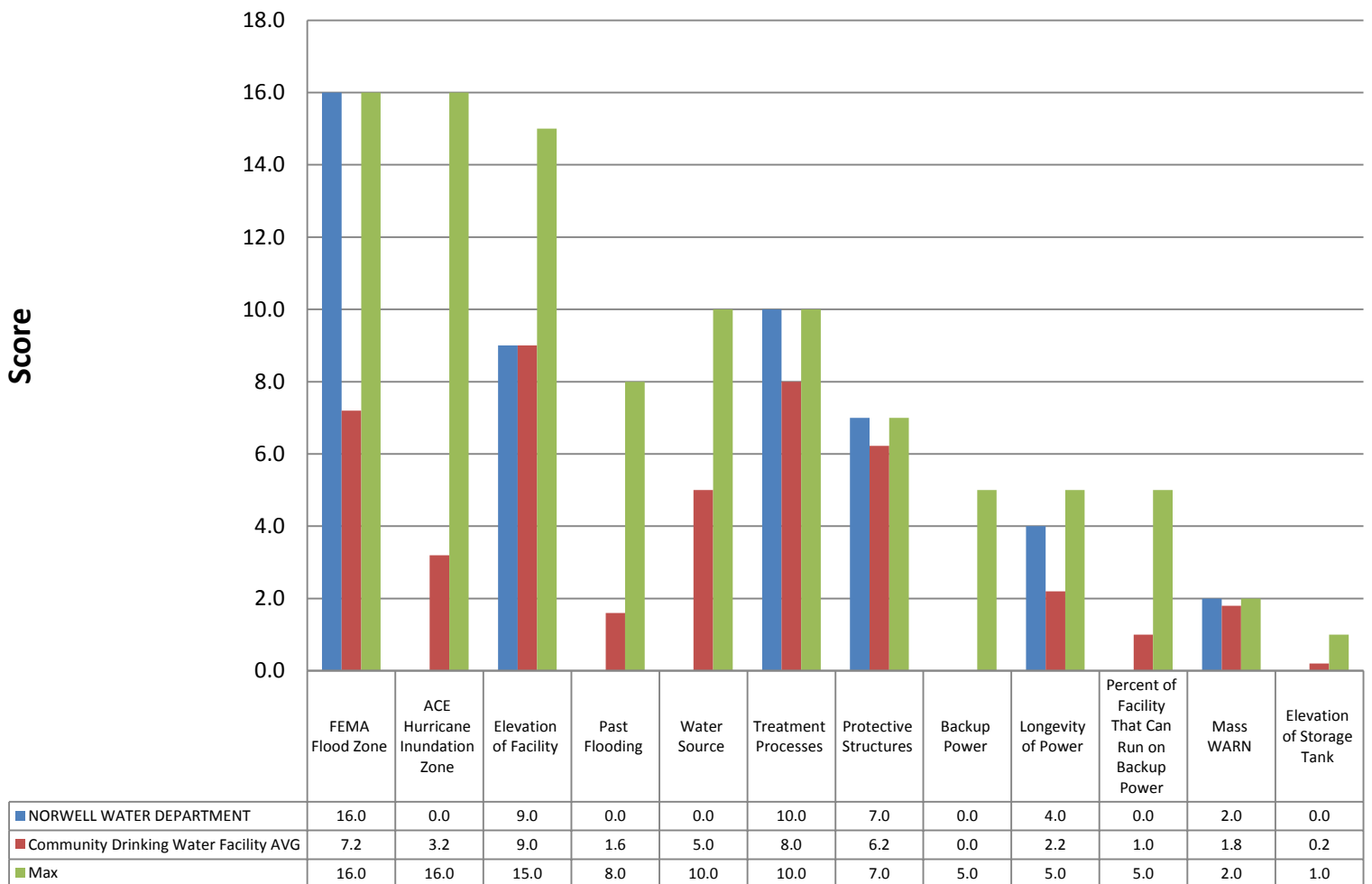
## Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal drinking water treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist drinking water treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

## Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

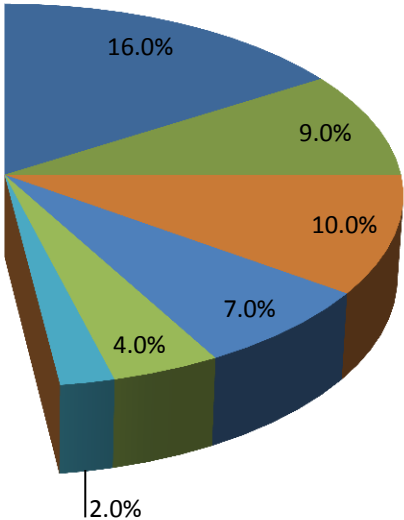
### Flood Risk Assessment – Norwell Water Department



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Norwell Water Department

*Maximum Possible Percentage per Factor*



- FEMA Flood Zone - 16%
- ACE Hurricane Inundation Zone - 16%
- Elevation of Facility - 15%
- Past Flooding - 8%
- Water Source - 10%
- Treatment Processes - 10%
- Protective Structures - 7%
- Backup Power - 5%
- Longevity of Power - 5%
- Percent of Facility That Can Run on Backup Power - 5%
- Mass WARN - 2%
- Elevation of Storage Tank - 1%

FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

**Resources and Assistance Available for Flood Resiliency Measures:**

Your facility was not found to be in any ACE Hurricane Inundation Zone, but was found to be in a FEMA Flood zone which is one of the more heavily weighted factors. However your facility did rank at a medium level for flooding and here are some areas where you may improve your score:

**Potential to decrease Risk Level:**

- Become a member of Mass WARN
- Install Protective Structures
- Increase longevity of backup power

**For More Information:**

Paul Niman,  
[Paul.niman@state.ma.us](mailto:Paul.niman@state.ma.us)  
 617-556-1166

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at Pleasant Water Treatment Facility

**LOW: 21/100**

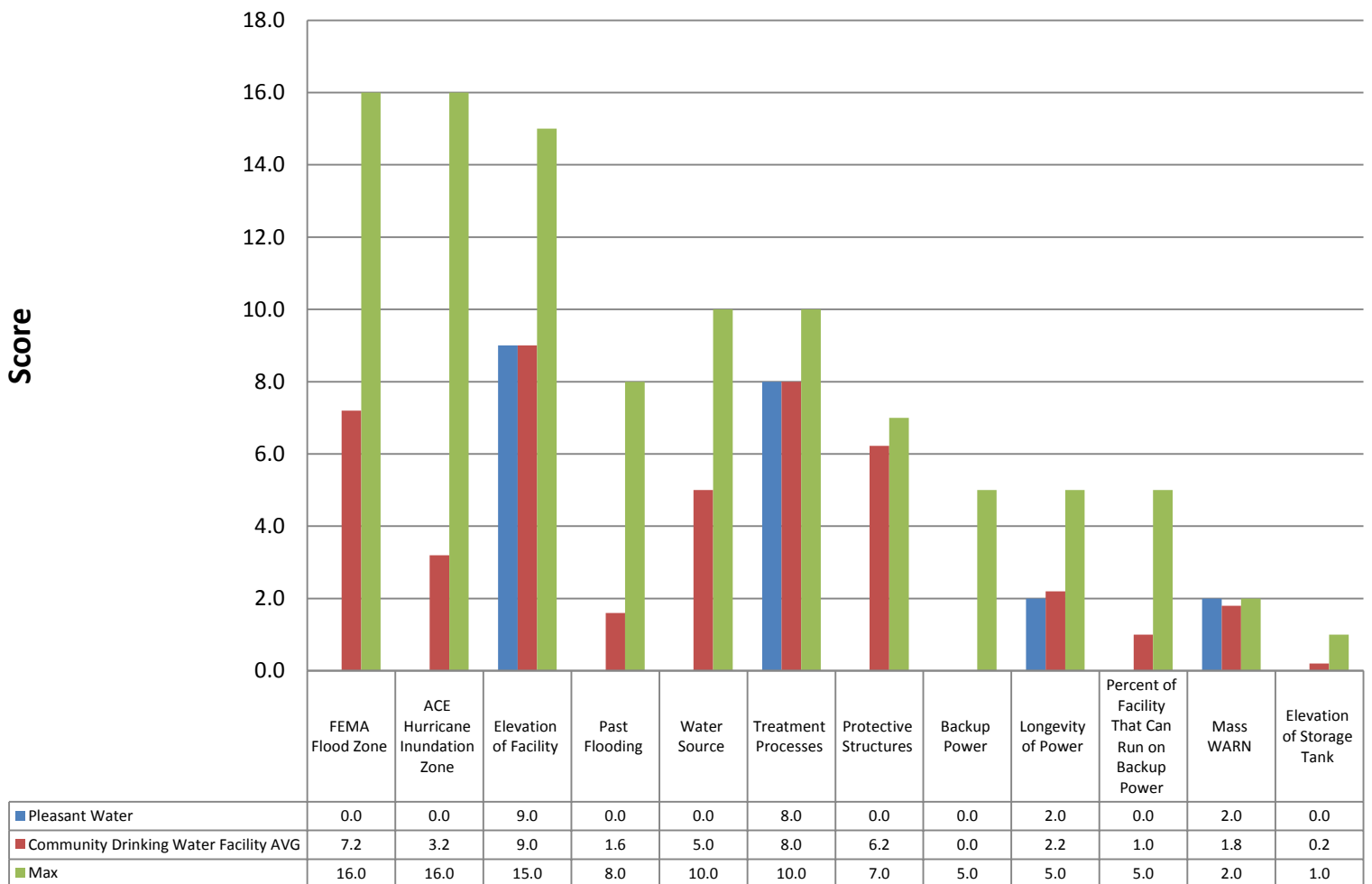
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal drinking water treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist drinking water treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

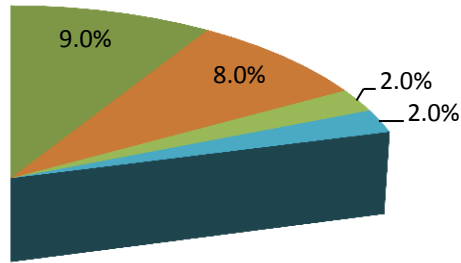
## Flood Risk Assessment – Pleasant Water



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Pleasant Water

*Maximum Possible Percentage per Factor*



- FEMA Flood Zone - 16%
- ACE Hurricane Inundation Zone - 16%
- Elevation of Facility - 15%
- Past Flooding - 8%
- Water Source - 10%
- Treatment Processes - 10%
- Protective Structures - 7%
- Backup Power - 5%
- Longevity of Power - 5%
- Percent of Facility That Can Run on Backup Power - 5%
- Mass WARN - 2%
- Elevation of Storage Tank - 1%

FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## **Resources and Assistance Available for Flood Resiliency Measures:**

Your facility is at a low flood risk, you do not fall into any FEMA Flood Zones or ACE Hurricane Inundation areas which are the two most heavily weighted factors. However here are some measures to take to further decrease your flood risk level:

### **Potential to decrease Risk Level:**

- Become a member of Mass WARN
- Increase longevity of backup power

### **For More Information:**

Paul Niman,  
[Paul.niman@state.ma.us](mailto:Paul.niman@state.ma.us)  
 617-556-1166

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at Rockport Water Department Treatment Facility

**MEDIUM: 39.5/100**

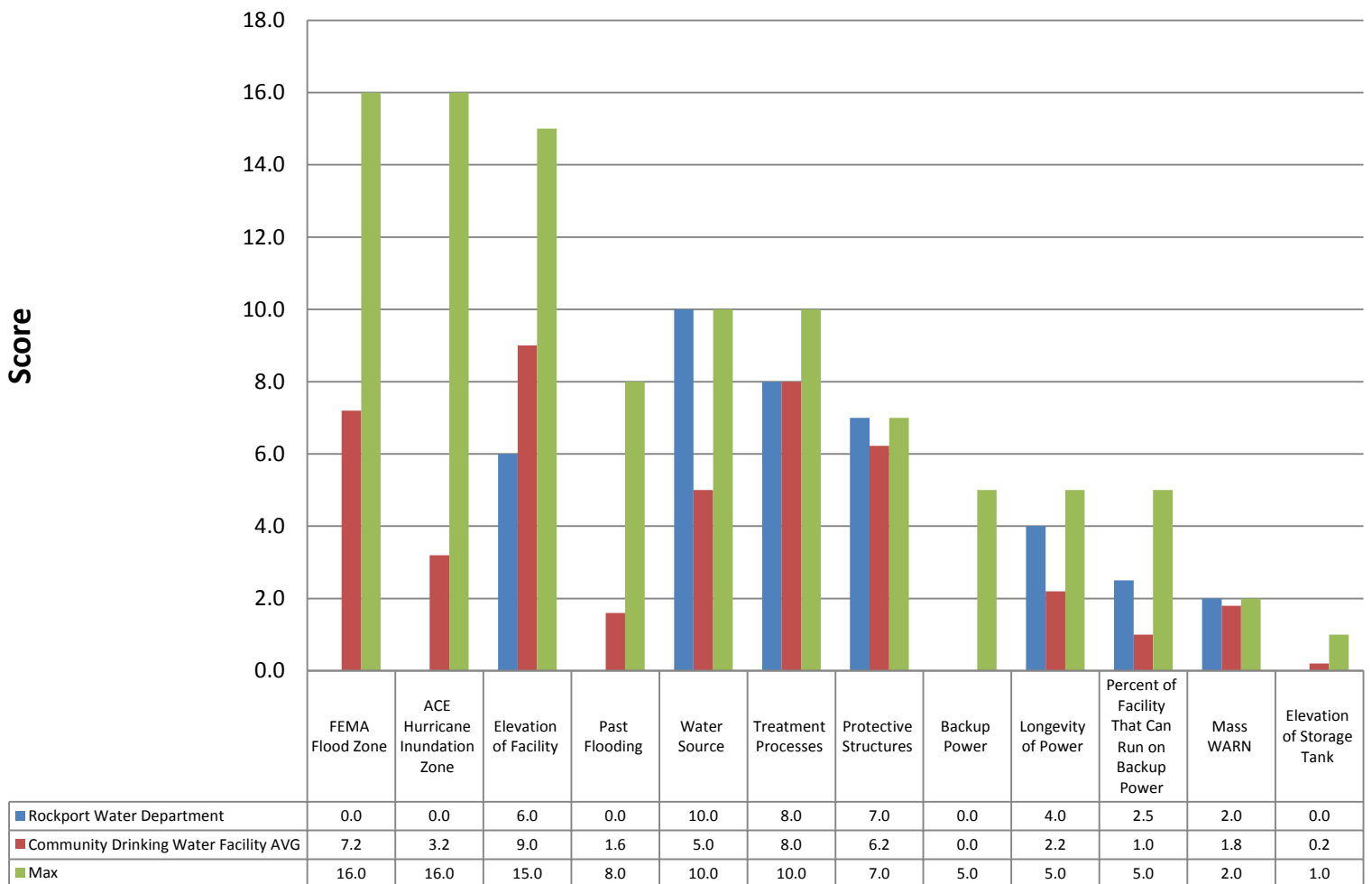
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal drinking water treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist drinking water treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

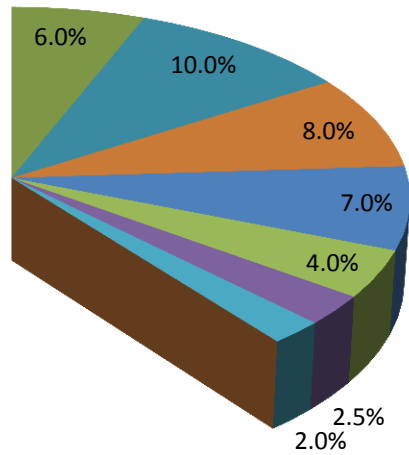
## Flood Risk Assessment – Rockport Water Department



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Rockport Water Department

*Maximum Possible Percentage per Factor*



- FEMA Flood Zone - 16%
- ACE Hurricane Inundation Zone - 16%
- Elevation of Facility - 15%
- Past Flooding - 8%
- Water Source - 10%
- Treatment Processes - 10%
- Protective Structures - 7%
- Backup Power - 5%
- Longevity of Power - 5%
- Percent of Facility That Can Run on Backup Power - 5%
- Mass WARN - 2%
- Elevation of Storage Tank - 1%

FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## **Resources and Assistance Available for Flood Resiliency Measures:**

Your facility was not found to be in any FEMA Flood Zone, or ACE Hurricane Inundation Zones which are the two factors that carry the most weight in the tool. Although your facility only ranked at a medium level, there are still actions that may be taken to decrease the facility's risk of flooding.

## **Potential to decrease Risk Level:**

- Become a member of Mass WARN
- Install Protective Structures
- Increase longevity of backup power

## **For More Information:**

Paul Niman,  
[Paul.niman@state.ma.us](mailto:Paul.niman@state.ma.us)  
 617-556-1166

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at Westport Senior Village Treatment Facility

**MEDIUM: 35/100**

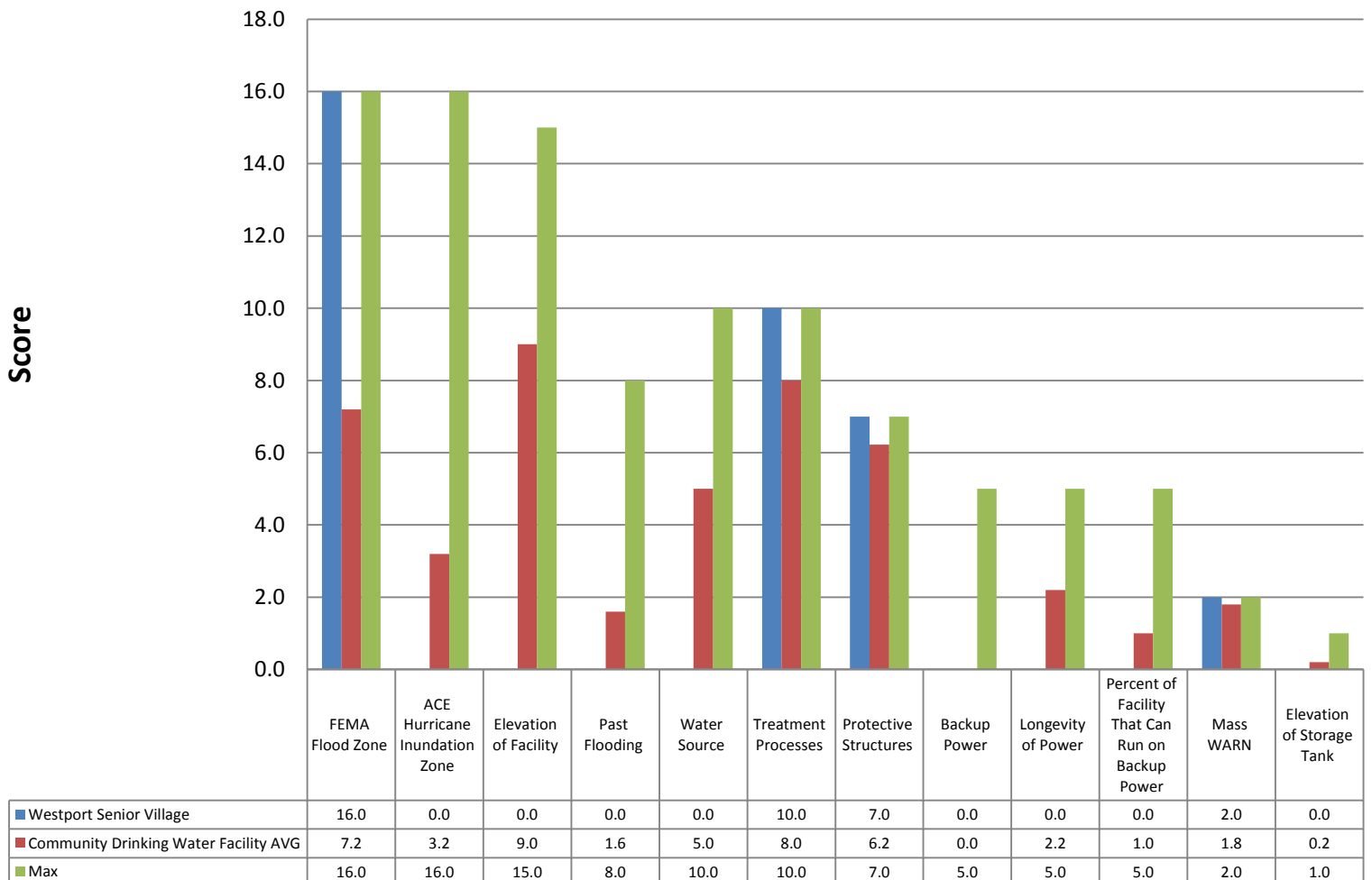
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal drinking water treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist drinking water treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

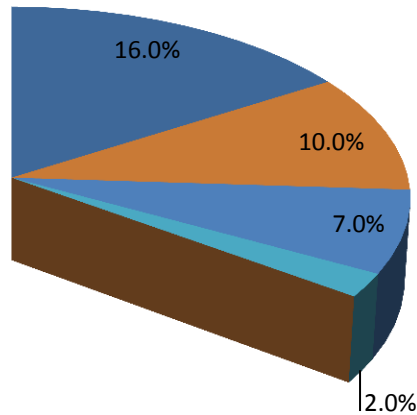
## Flood Risk Assessment – Westport Senior Village



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Westport Senior Village

*Maximum Possible Percentage per Factor*



- FEMA Flood Zone - 16%
- ACE Hurricane Inundation Zone - 16%
- Elevation of Facility - 15%
- Past Flooding - 8%
- Water Source - 10%
- Treatment Processes - 10%
- Protective Structures - 7%
- Backup Power - 5%
- Longevity of Power - 5%
- Percent of Facility That Can Run on Backup Power - 5%
- Mass WARN - 2%
- Elevation of Storage Tank - 1%

FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility was found to be in a FEMA Flood Zone, but was not found to be in an ACE Hurricane Inundation Zone. However your facility did rank at a medium level for flooding because there are some areas where you may improve:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Install Protective Structures

### **For More Information:**

Paul Niman,  
[Paul.niman@state.ma.us](mailto:Paul.niman@state.ma.us)  
 617-556-116



# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Barnstable Wastewater Treatment Facility

**MEDIUM: 41.8/100**

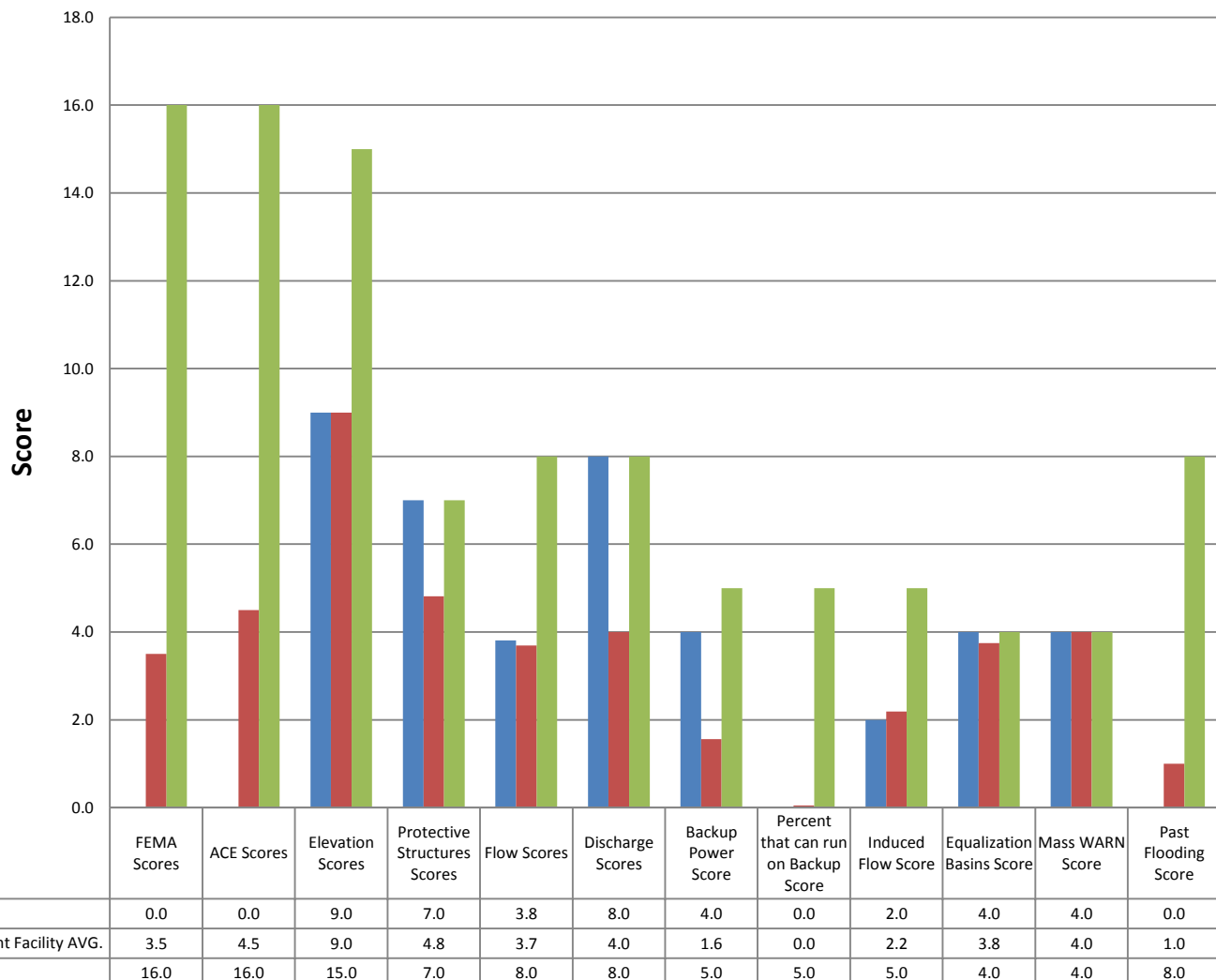
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

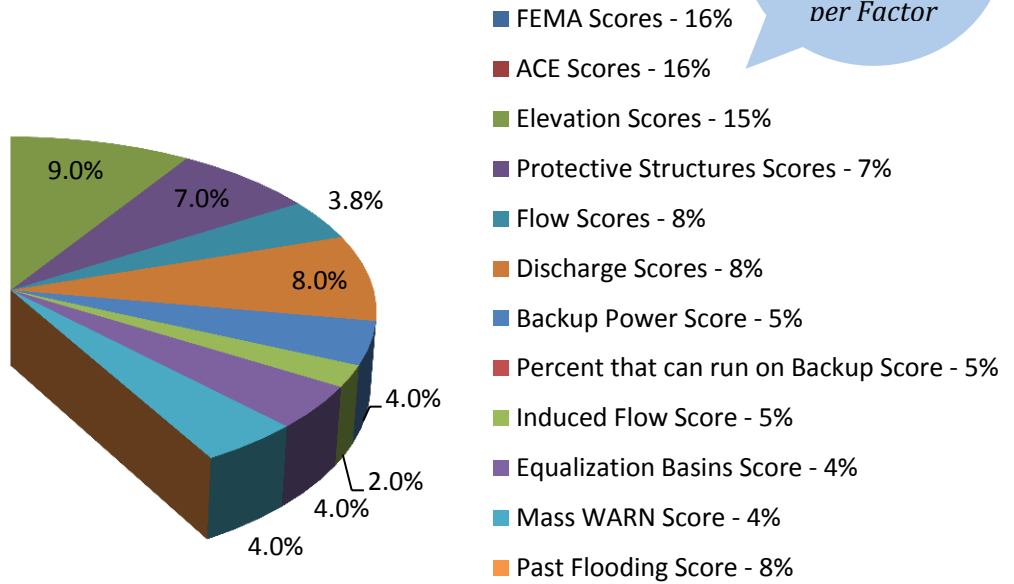
The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

**Flood Risk Assessment - Barnstable**



# BARNSTABLE

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Though your facility is only at a medium risk level, there are some factors that you may take into consideration to lower your risk level.

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Create Protective Structures

### **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Scituate Wastewater Treatment Facility

**HIGH: 68.34/100**

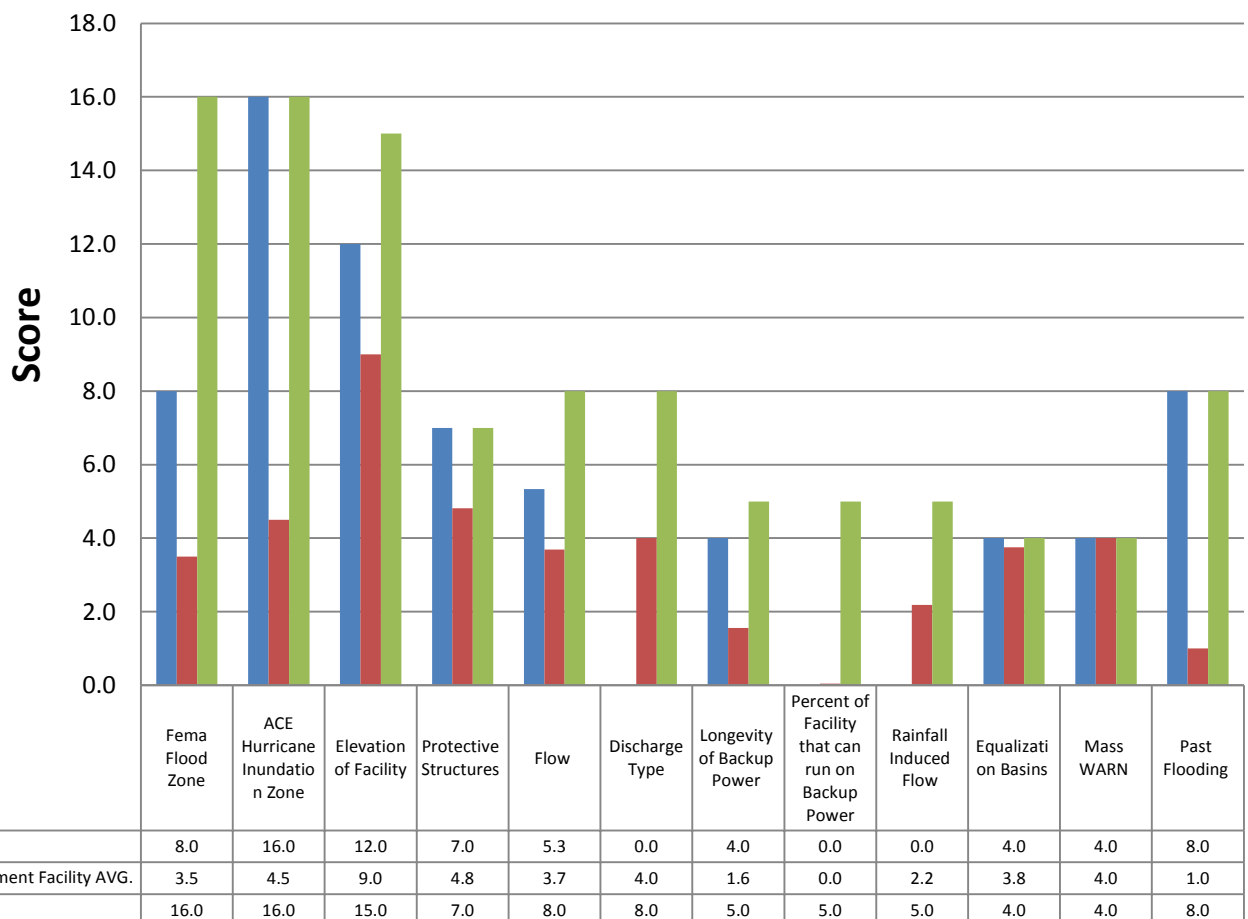
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

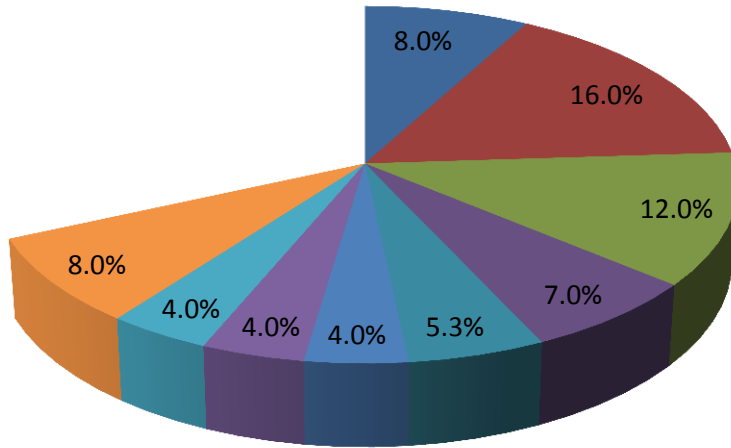
## Flood Risk Assessment - Scituate



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Scituate

*Maximum Possible Percentage per Factor*



- Fema Scores - 16%
- ACE Scores - 16%
- Elevation Scores - 15%
- Protective Structures Scores - 7%
- Flow Scores - 8%
- Discharge Scores - 8%
- Backup Power Score - 5%
- Percent that can run on Backup Score - 5%
- Induced Flow Score - 5%
- Equalization Basins Score - 4%
- Mass WARN Score - 4%
- Past Flooding Score - 8%

FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Although your facility lays in a FEMA flood zone as well as an ACE Hurricane Inundation area which makes up for 24% of your overall risk score, there are proactive measures that may be taken to decrease the facility's overall risk assessment score:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Increase longevity of backup power
- Become a member of Mass WARN

### **For More Information:**

Alan, Slater

[Alan.Slater@state.ma.us](mailto:Alan.Slater@state.ma.us)

617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Chatham Wastewater Treatment Facility

**MEDIUM: 34.6/100**

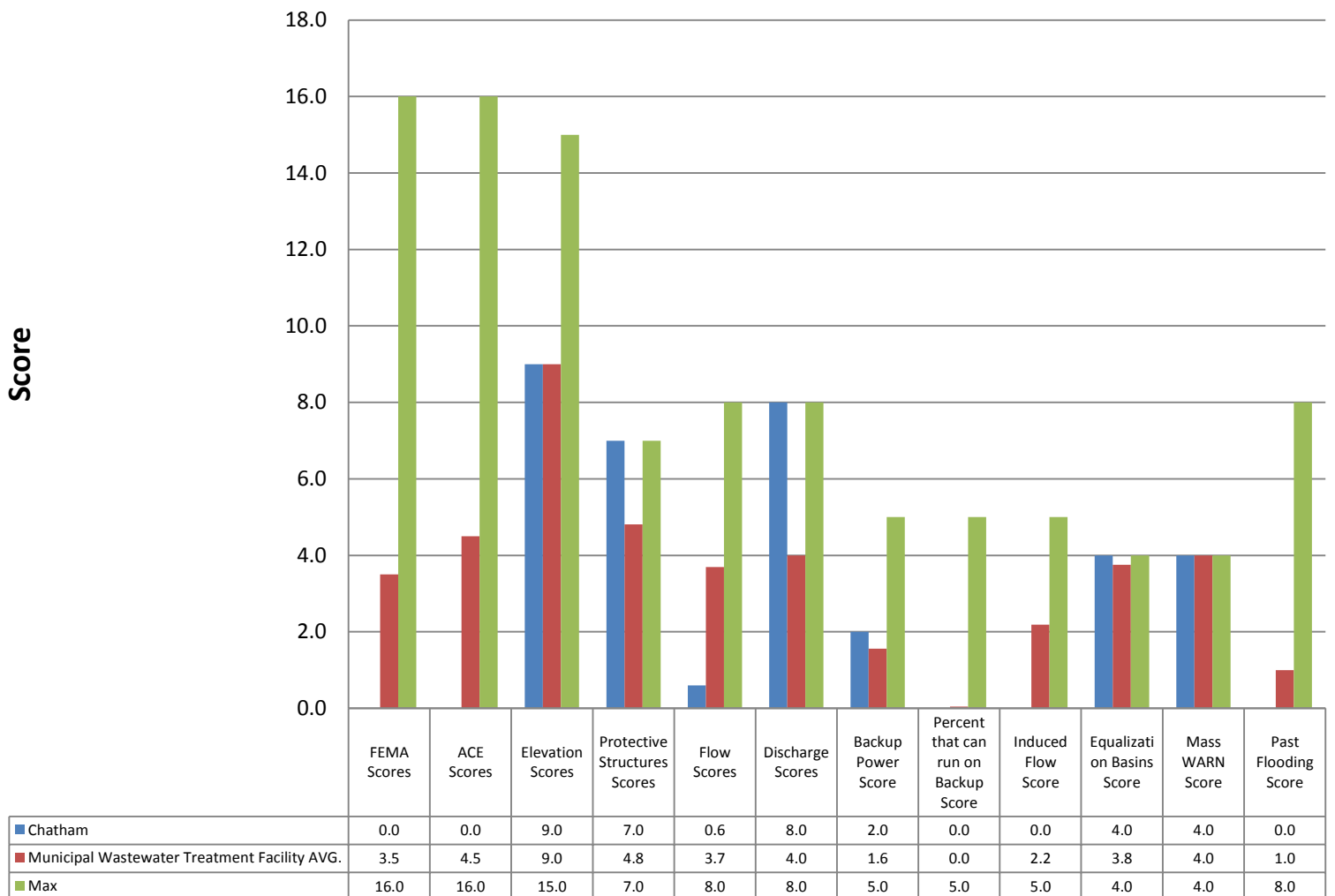
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

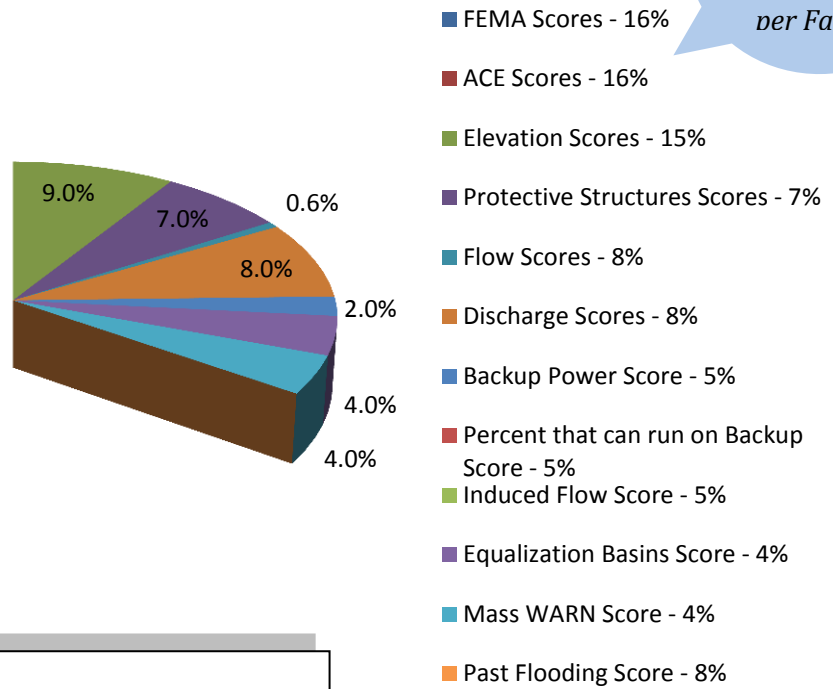
The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

## Flood Risk Assessment - Chatham



# Chatham

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility was not found to be in any FEMA Flood Zone, or ACE Hurricane Inundation Zones which are the two factors that carry the most weight in the tool. Although your facility only ranked at a medium level, there are still actions that may be taken to decrease the facility's risk of flooding.

## Potential to decrease Risk Level:

- Become a member of Mass WARN

## **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Dartmouth Wastewater Treatment Facility

**LOW: 28.4/100**

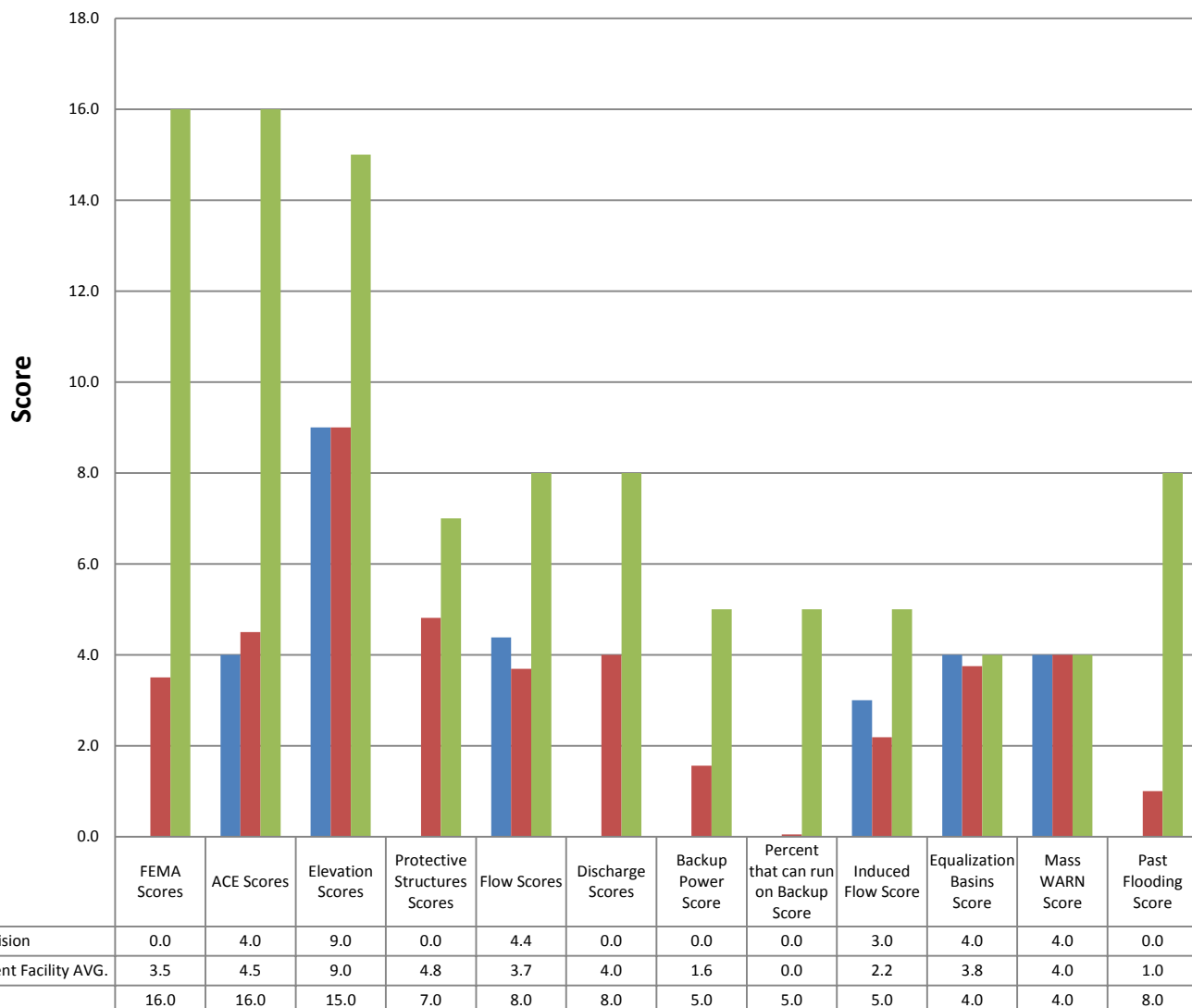
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

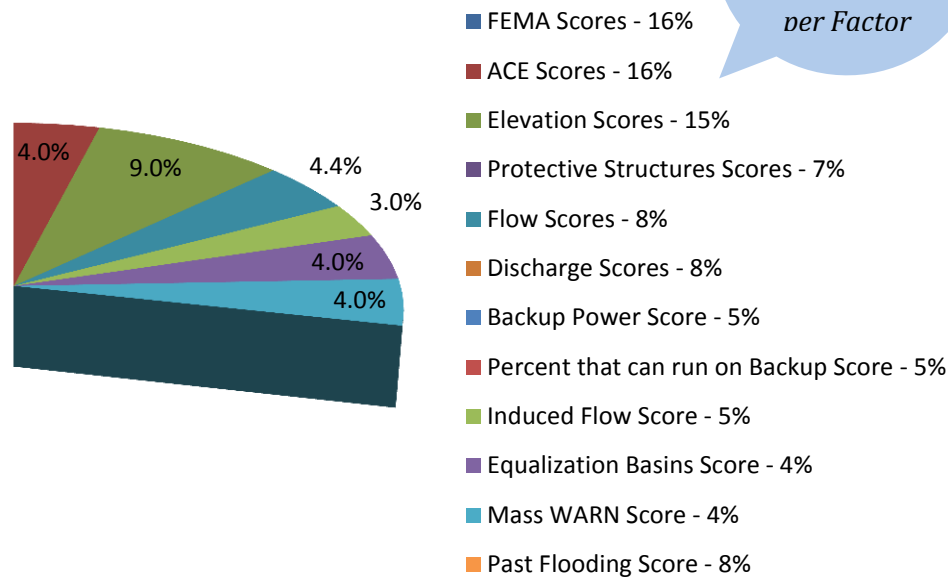
The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

**Flood Risk Assessment - Dartmouth**



# Dartmouth Water Pollution Division

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility is at a low flood risk, you do not fall into any FEMA Flood Zones or ACE Hurricane Inundation areas which are the two most heavily weighted factors. However here are some measures to take to further decrease your flood risk level:

### Potential to decrease Risk Level:

- Become a member of Mass WARN

### **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749



# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

**Flood Risk Score at the Falmouth Wastewater Treatment Facility**

**LOW: 32.3/100**

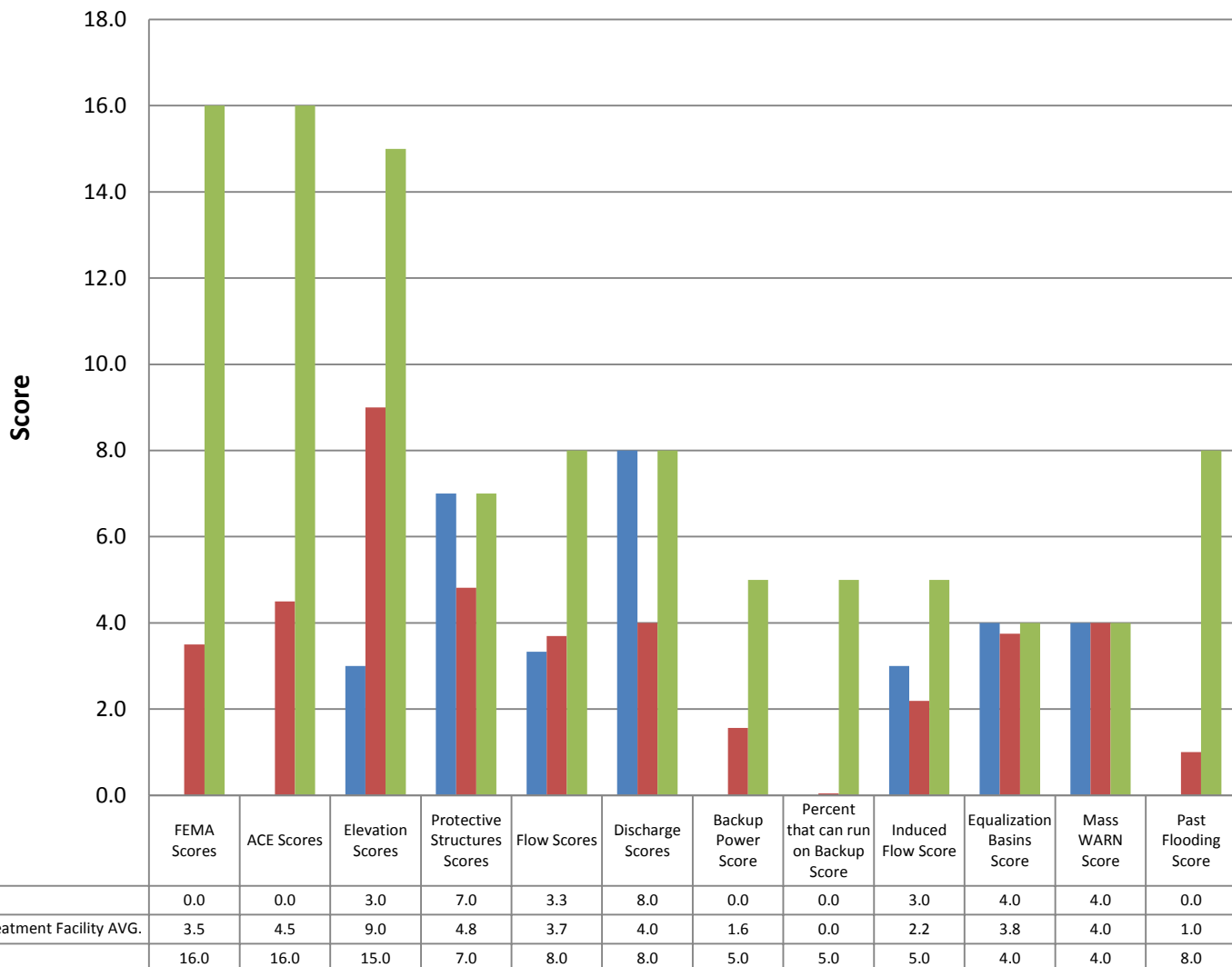
## Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

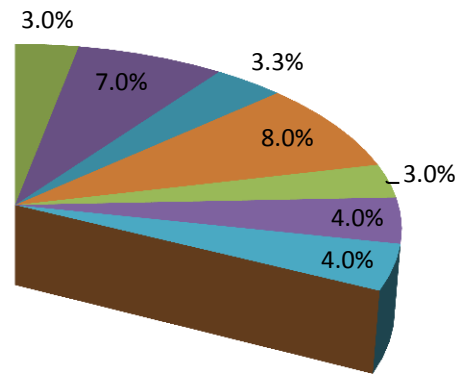
## Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

**Flood Risk Assessment - Falmouth**



# Falmouth



*Maximum Possible Percentage per Factor*

- FEMA Scores - 16%
- ACE Scores - 16%
- Elevation Scores - 15%
- Protective Structures Scores - 7%
- Flow Scores - 8%
- Discharge Scores - 8%
- Backup Power Score - 5%
- Percent that can run on Backup Score - 5%
- Induced Flow Score - 5%
- Equalization Basins Score - 4%
- Mass WARN Score - 4%
- Past Flooding Score - 8%

FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility is at a low flood risk, you do not fall into any FEMA Flood Zones or ACE Hurricane Inundation areas which are the two most heavily weighted factors. However here are some measures to take to further decrease your flood risk level:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Create Protective Structures

### **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Hull Wastewater Treatment Facility

**MEDIUM: 53.8/100**

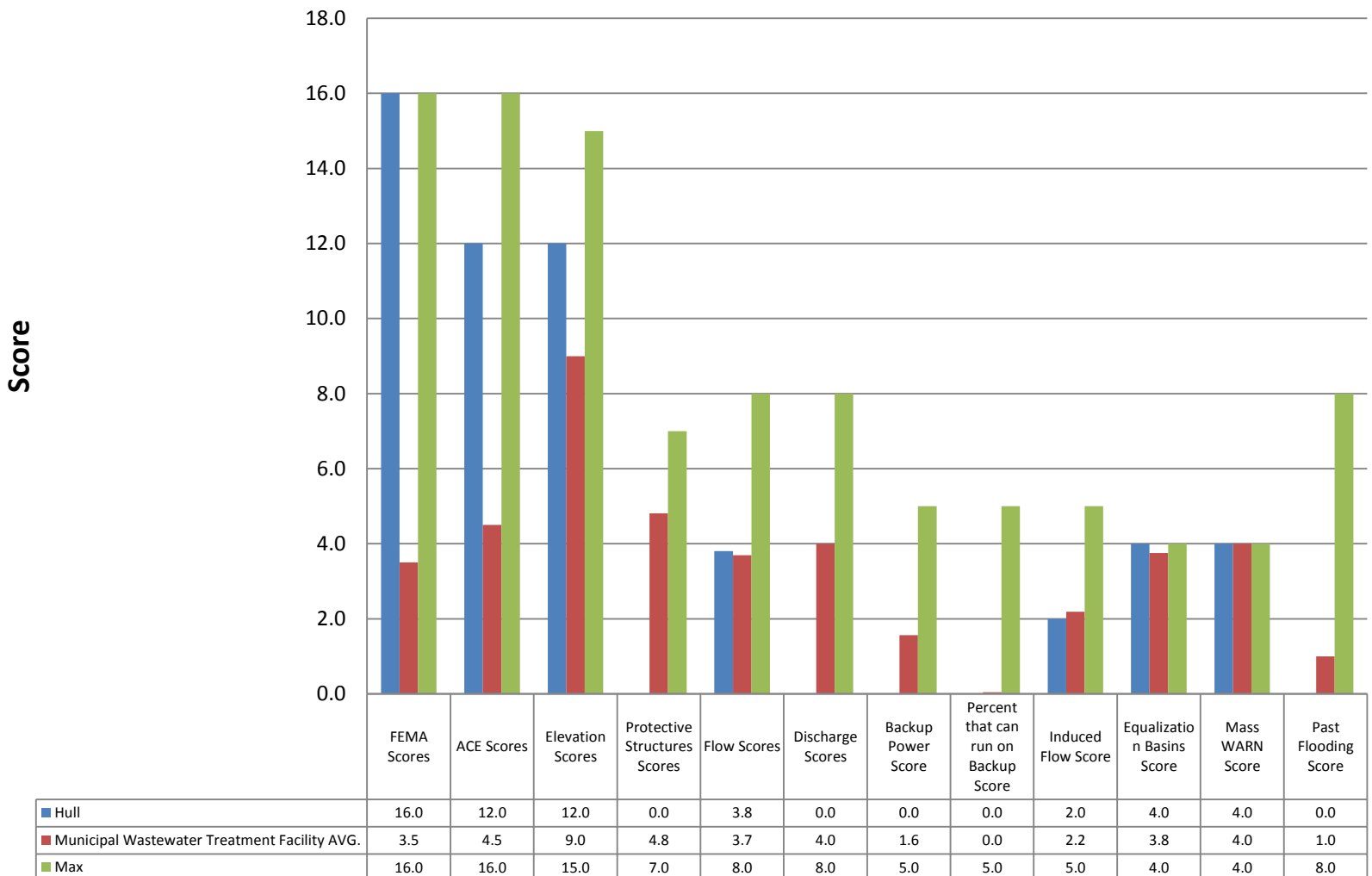
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

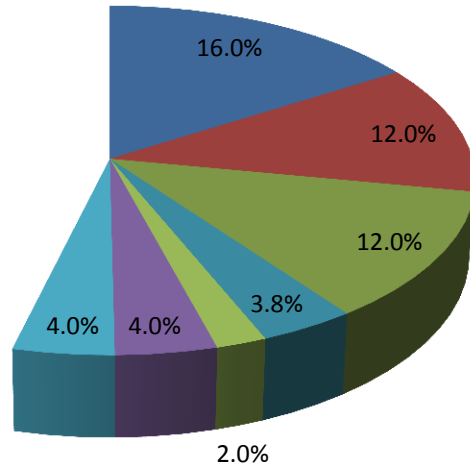
### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

## Flood Risk Assessment - Hull



# Hull



*Maximum Possible Percentage per Factor*

- FEMA Scores - 16%
- ACE Scores - 16%
- Elevation Scores - 15%
- Protective Structures Scores - 7%
- Flow Scores - 8%
- Discharge Scores - 8%
- Backup Power Score - 5%
- Percent that can run on Backup Score - 5%
- Induced Flow Score - 5%
- Equalization Basins Score - 4%
- Mass WARN Score - 4%
- Past Flooding Score - 8%

FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Although your facility lays in FEMA Flood zones and ACE Hurricane zones which make up a significant portion of your risk level, there are areas in some of the factors where proactive measures may be taken to mitigate the effects of flooding which would then lower your facility's risk level:

### Potential to decrease Risk Level:

- Become a member of Mass WARN

### **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Kingston Wastewater Treatment Facility

**LOW: 32.6/100**

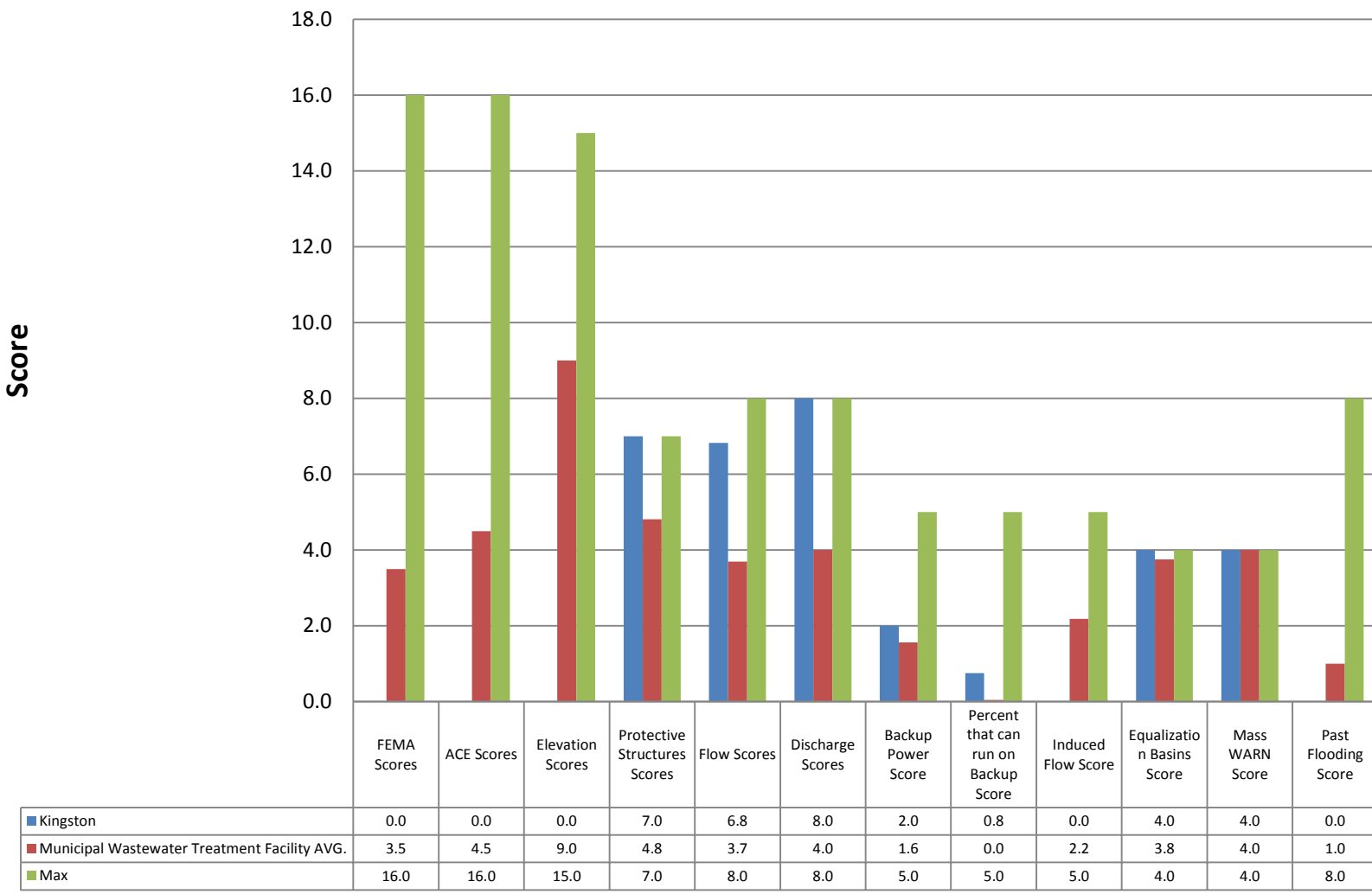
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

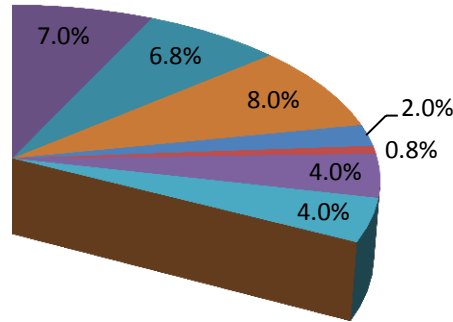
### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

## Flood Risk Assessment - Kingston



# Kingston



*Maximum Possible Percentage per Factor*

- FEMA Scores - 16%
- ACE Scores - 16%
- Elevation Scores - 15%
- Protective Structures Scores - 7%
- Flow Scores - 8%
- Discharge Scores - 8%
- Backup Power Score - 5%
- Percent that can run on Backup Score - 5%
- Induced Flow Score - 5%
- Equalization Basins Score - 4%
- Mass WARN Score - 4%
- Past Flooding Score - 8%

FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility is at a low flood risk, you do not fall into any FEMA Flood Zones or ACE Hurricane Inundation areas which are the two most heavily weighted factors. However here are some measures to take to further decrease your flood risk level:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Create Protective Structures

### **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Lynn Wastewater Treatment Facility

**MEDIUM: 56.8/100**

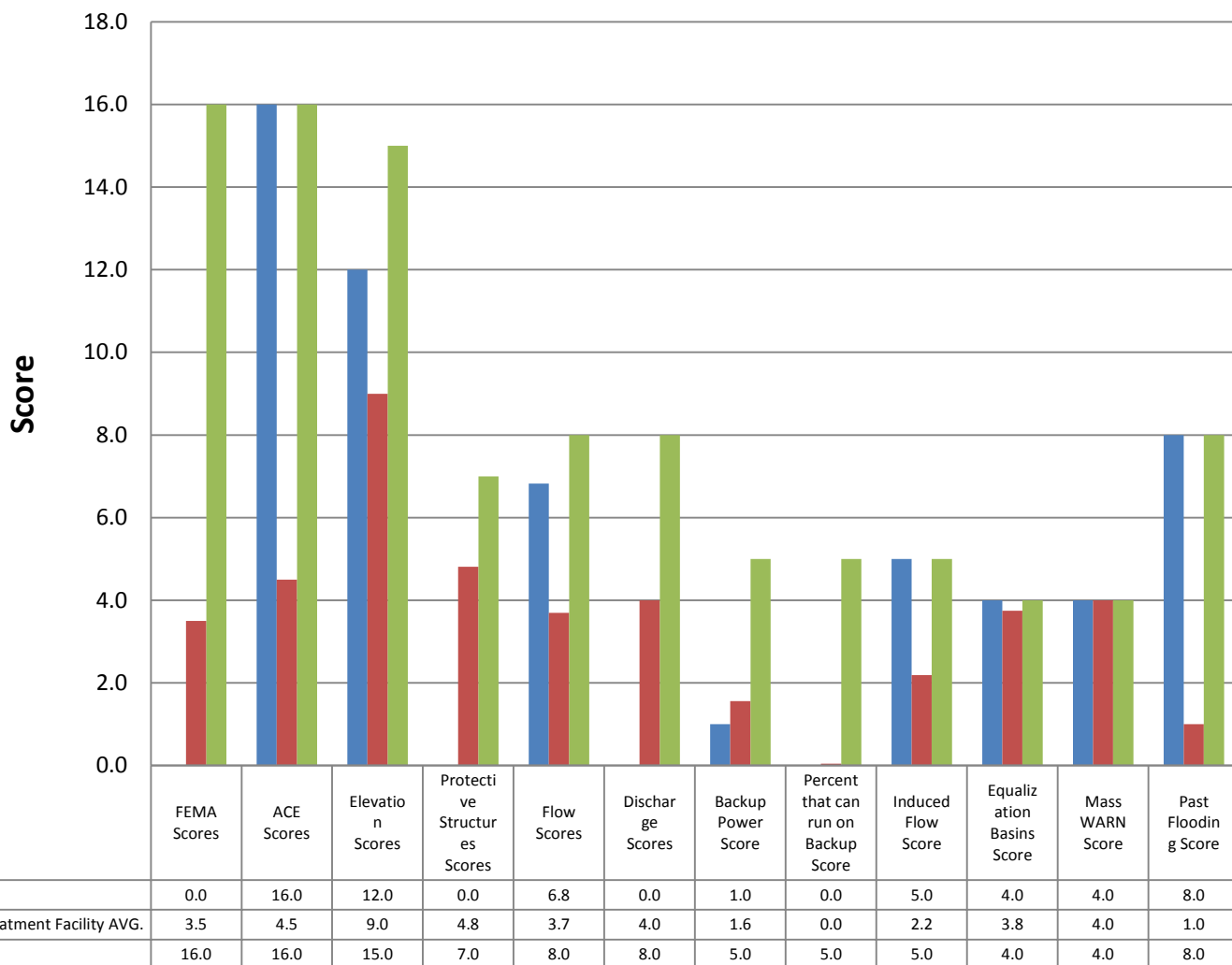
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

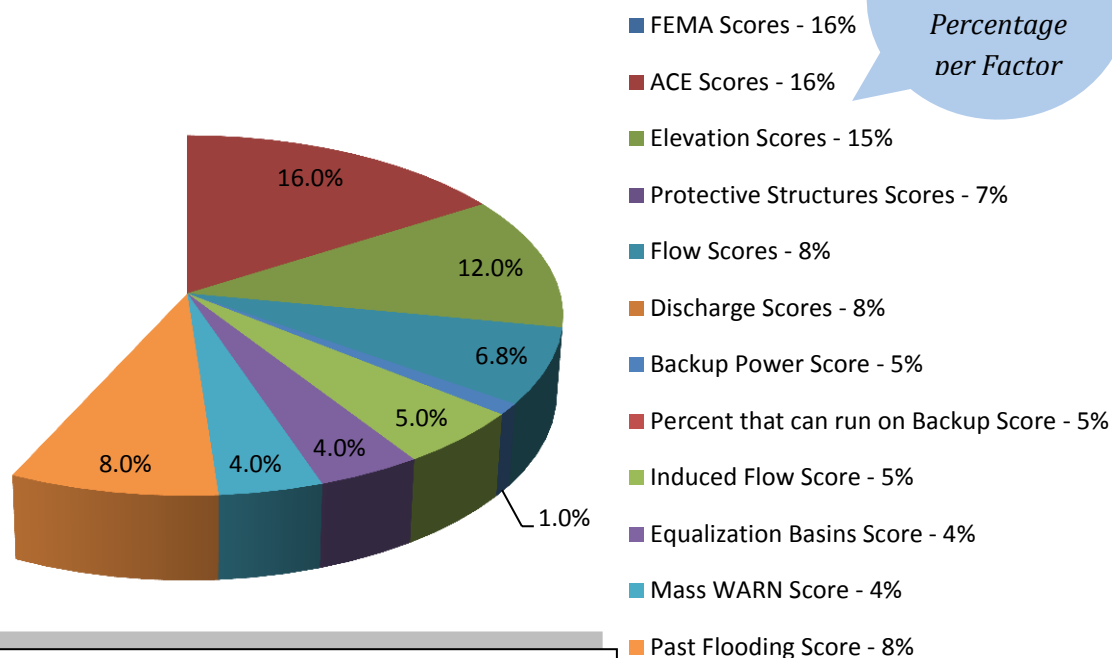
The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

**Flood Risk Assessment - Lynn**



## Lynn c/o U.S. Filter

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

### Resources and Assistance Available for Flood Resiliency Measures:

Your facility was not found to be in any FEMA Flood Zone, and ranked in one of the 4 categories when it came to observing the ACE categories. However your facility did rank at a medium level for flooding because there are some areas where you may improve:

### Potential to decrease Risk Level:

- Become a member of Mass WARN

### **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749



# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Manchester By The Sea Wastewater Treatment Facility

**MEDIUM: 54.8/100**

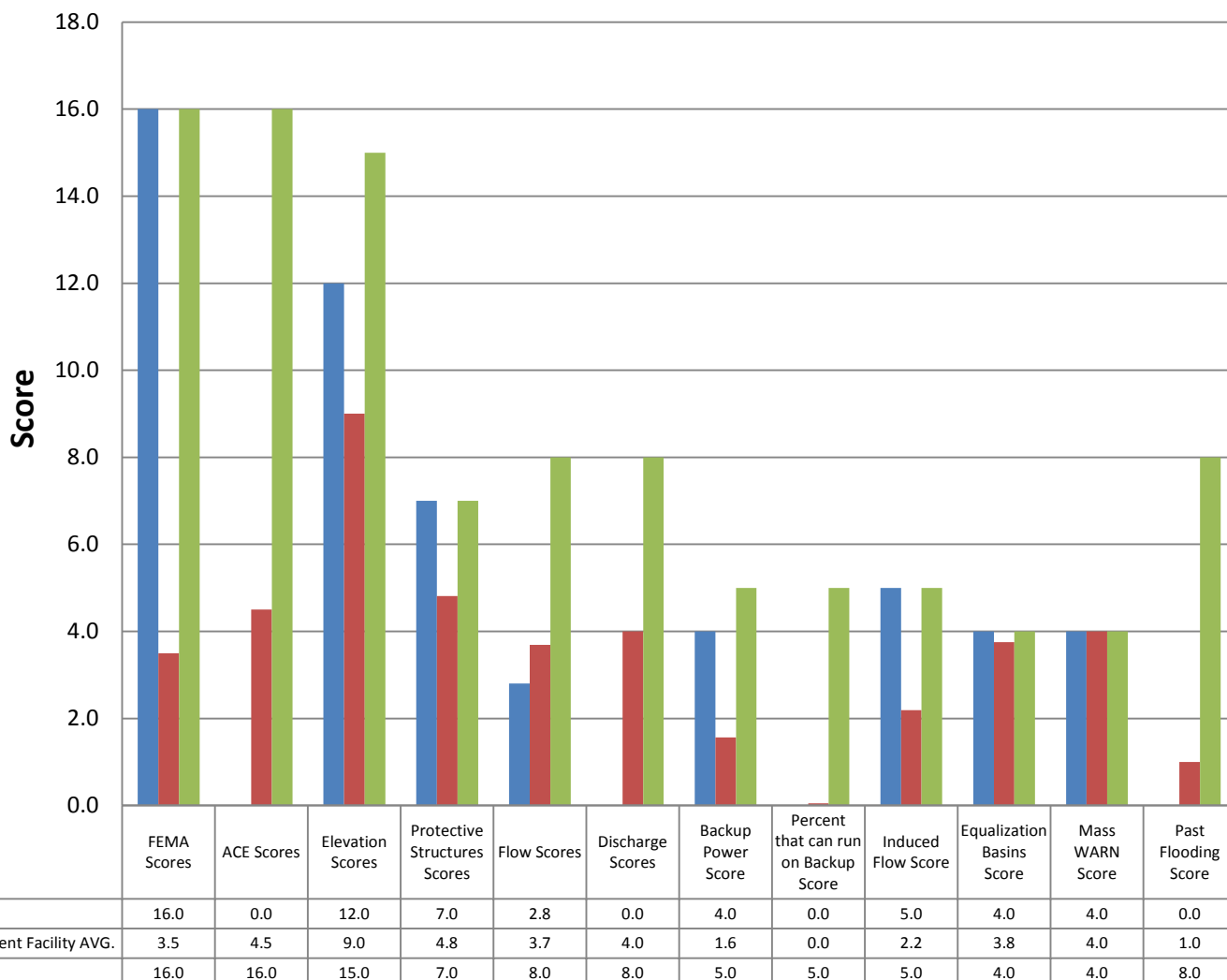
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

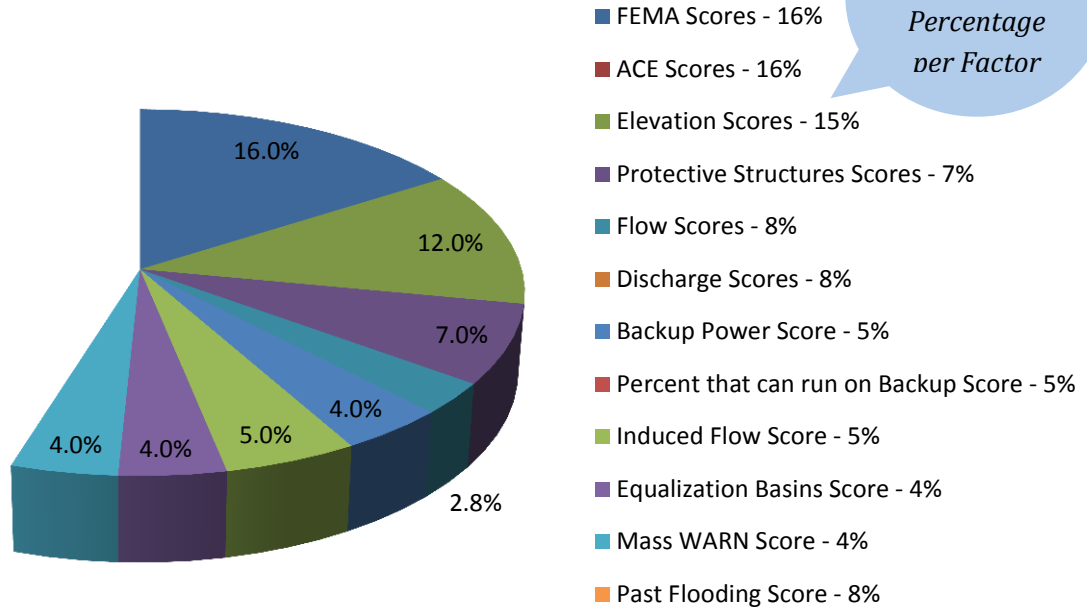
The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

**Flood Risk Assessment - Manchester By The Sea**



# Manchester By The Sea

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Although your facility lies in a FEMA Flood zone which makes up a significant portion of your risk level, there are areas in some of the factors where proactive measures may be taken to mitigate the effects of flooding which would then lower your facility's risk level:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Create protective structures
- Increase longevity of backup power

### **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the MOLES Wastewater Treatment Facility

**MEDIUM: 32.6/100**

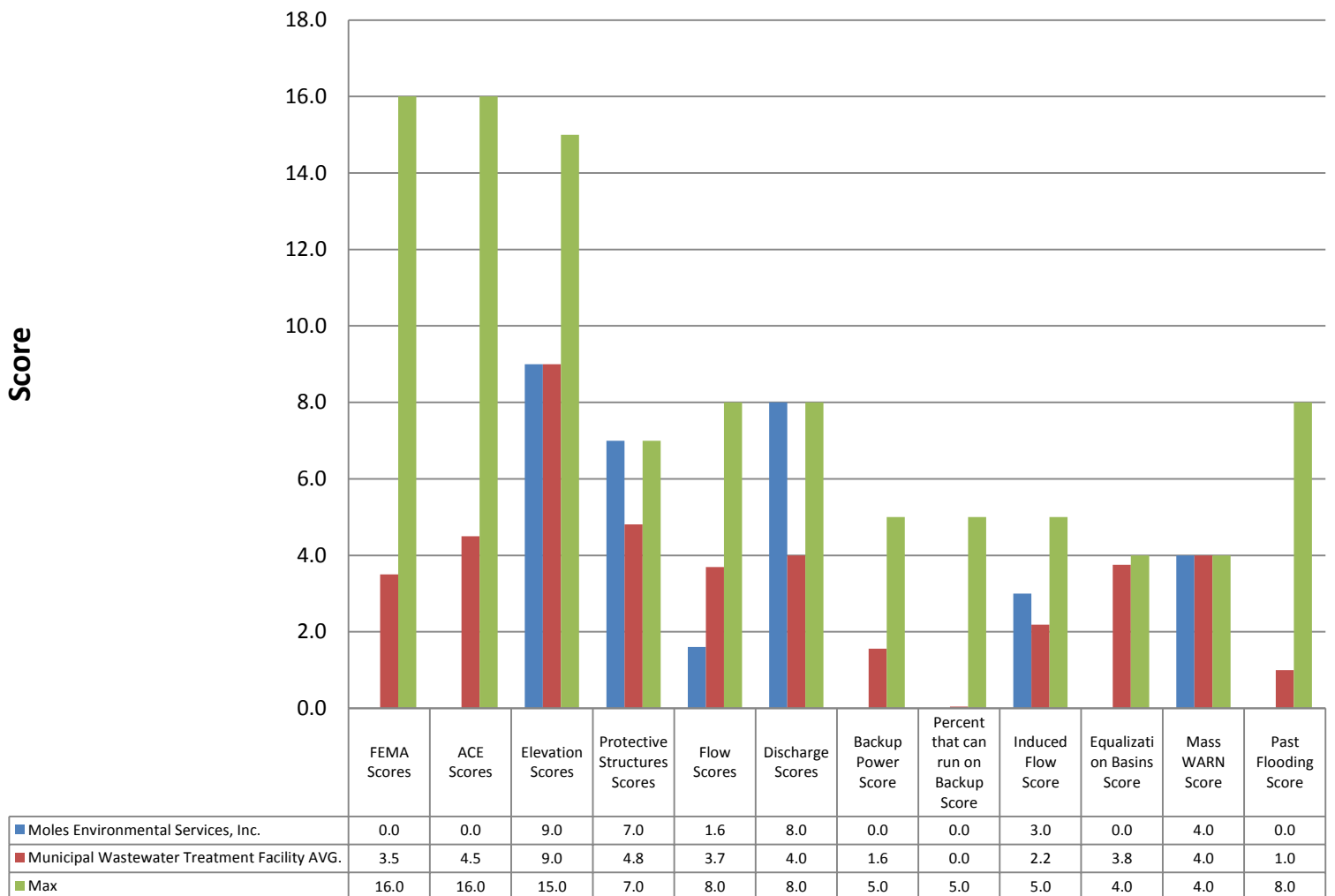
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

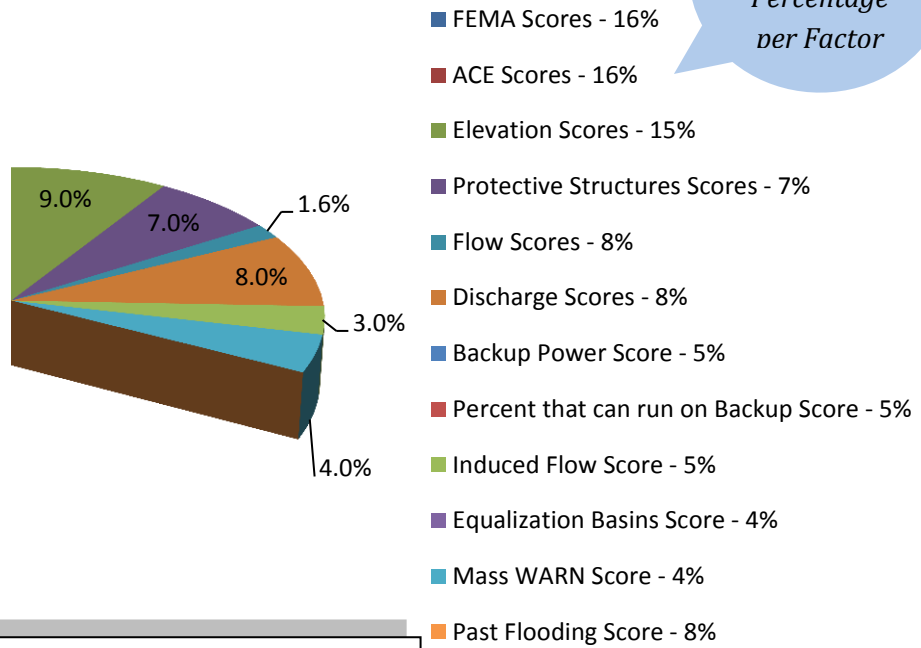
The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

## Flood Risk Assessment - Moles Environmental Services, Inc.



# Moles Environmental Services, Inc.

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility is at a low flood risk, you do not fall into any FEMA Flood Zones or ACE Hurricane Inundation areas which are the two most heavily weighted factors. However here are some measures to take to further decrease your flood risk level:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Develop a method to increase the percentage of the facility that is operational on backup power

### **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the MWRA – Deer Island Plant Wastewater Treatment Facility

**MEDIUM: 37.3/100**

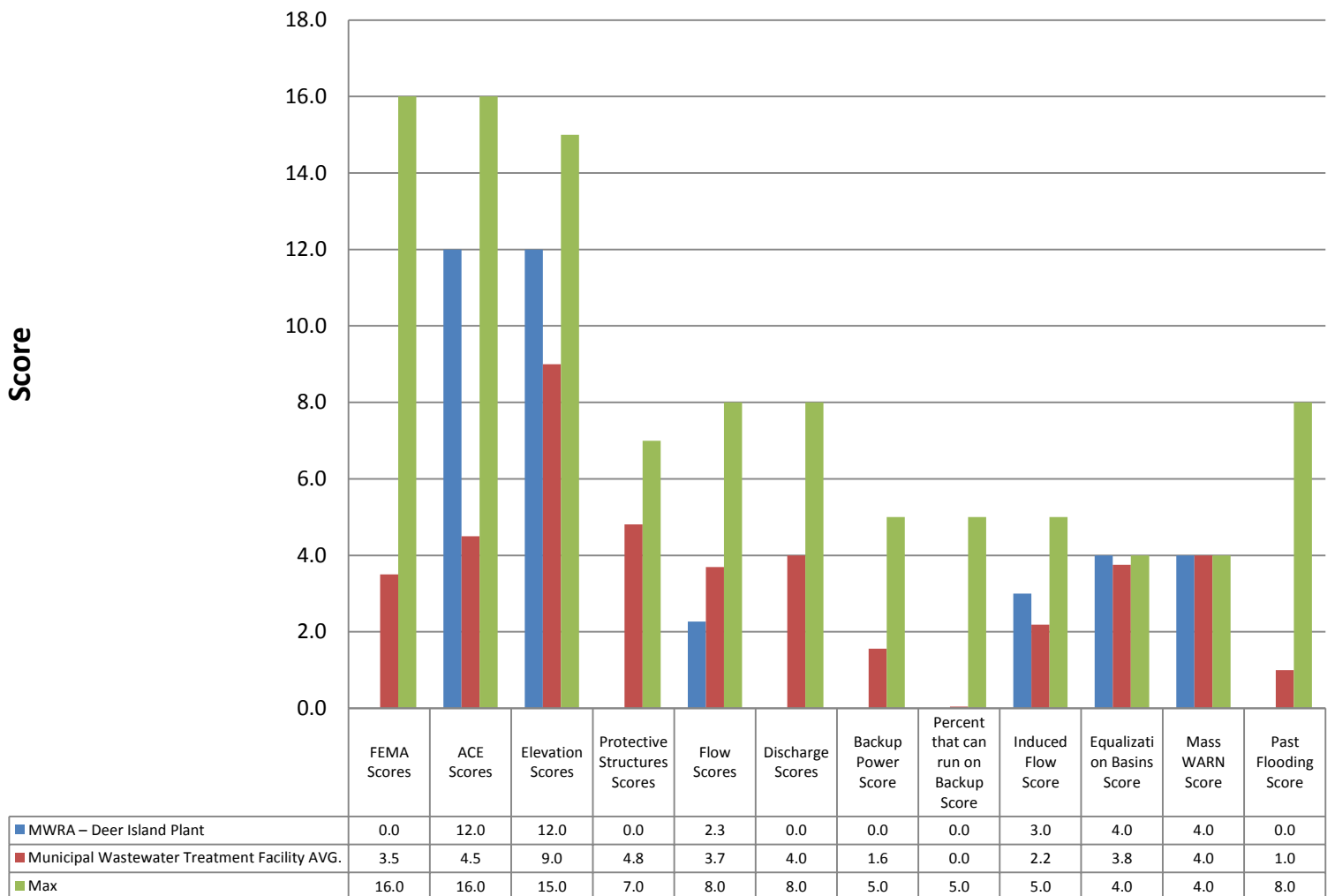
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

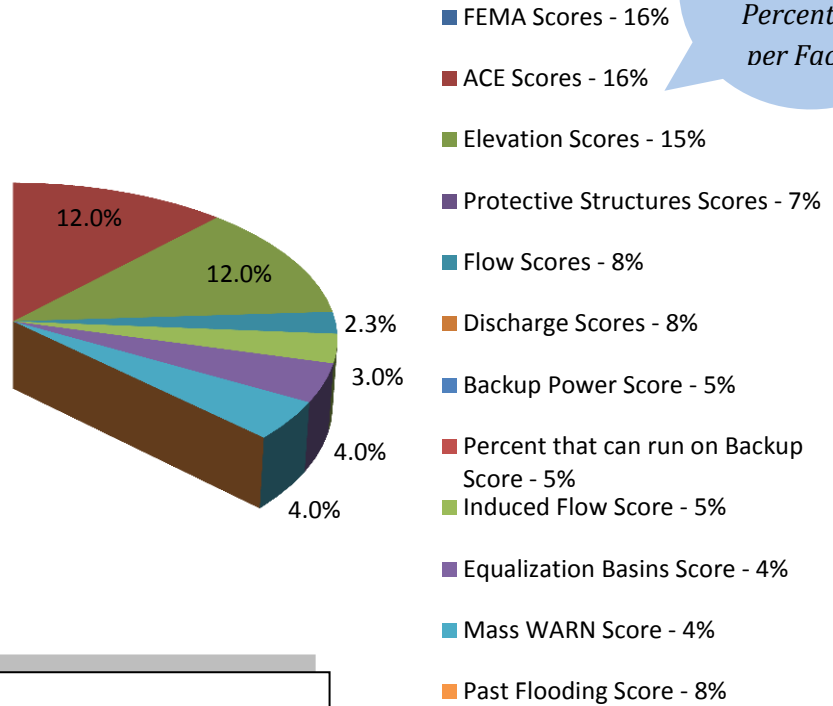
The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

## Flood Risk Assessment - MWRA – Deer Island Plant



# MWRA – Deer Island Plant

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility was not found to be in any FEMA Flood Zone, and ranked in one of the 4 categories when it came to observing the ACE categories. However your facility did rank at a medium level for flooding because there are some areas where you may improve:

## Potential to decrease Risk Level:

- Become a member of Mass WARN

## **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Nantucket (Surfside) Wastewater Treatment Facility

**MEDIUM: 45/100**

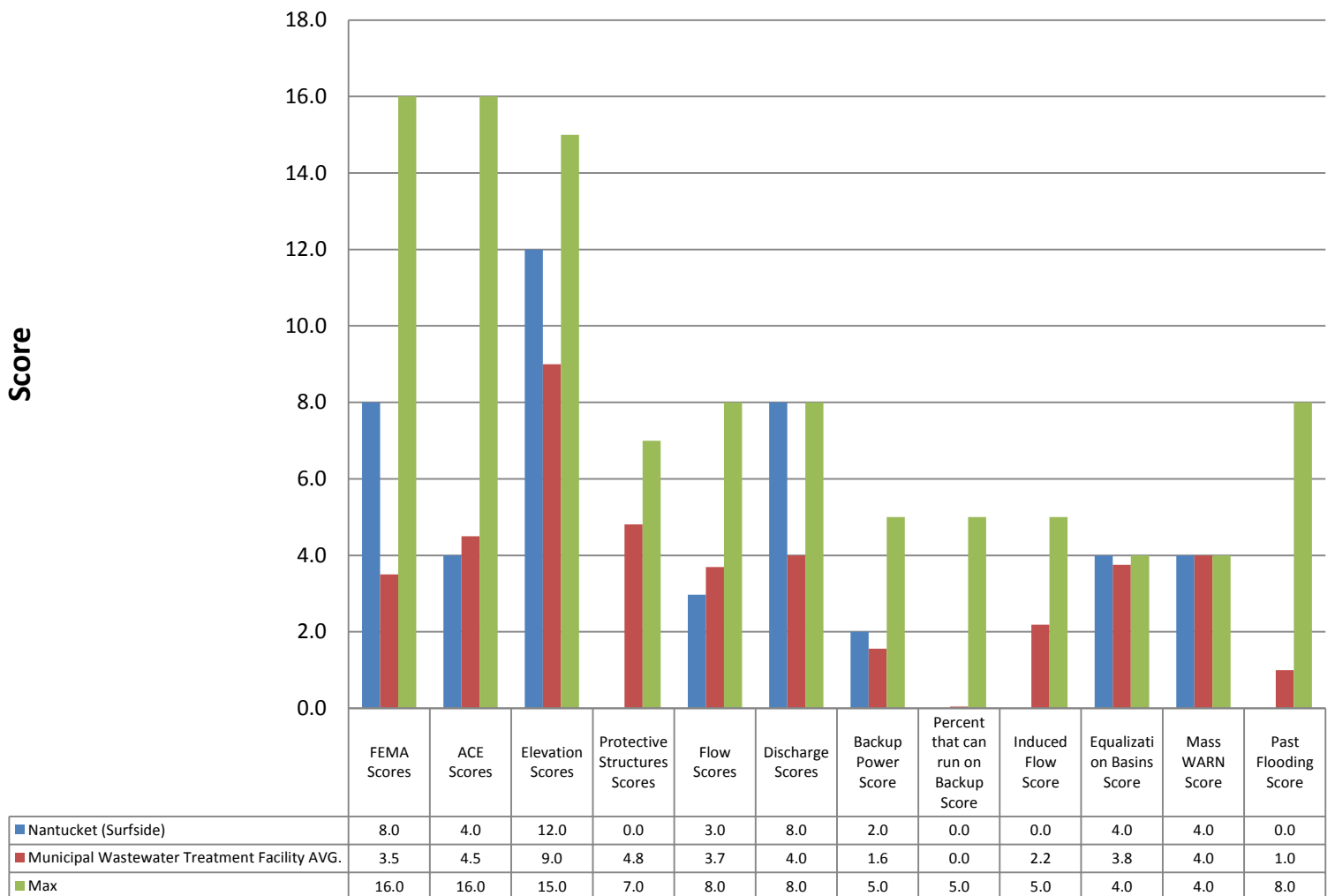
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

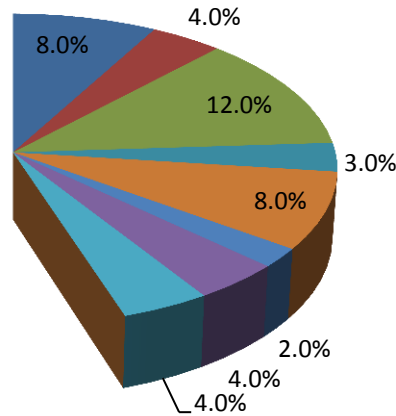
The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

## Flood Risk Assessment - Nantucket (Surfside)



# Nantucket (Surfside)

*Maximum Possible Percentage per Factor*



- FEMA Scores - 16%
- ACE Scores - 16%
- Elevation Scores - 15%
- Protective Structures Scores - 7%
- Flow Scores - 8%
- Discharge Scores - 8%
- Backup Power Score - 5%
- Percent that can run on Backup Score - 5%
- Induced Flow Score - 5%
- Equalization Basins Score - 4%
- Mass WARN Score - 4%
- Past Flooding Score - 8%

FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility was found to be in a FEMA Flood Zone, and ACE Hurricane Inundation Zone which make up a significant portion of your risk level. Although your facility only ranked at a medium level, there are still actions that may be taken to decrease the facility's risk of flooding.

## Potential to decrease Risk Level:

- Become a member of Mass WARN

## **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749



# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

**Flood Risk Score at the New Bedford Wastewater Treatment Facility**  
**MEDIUM: 50.3/100**

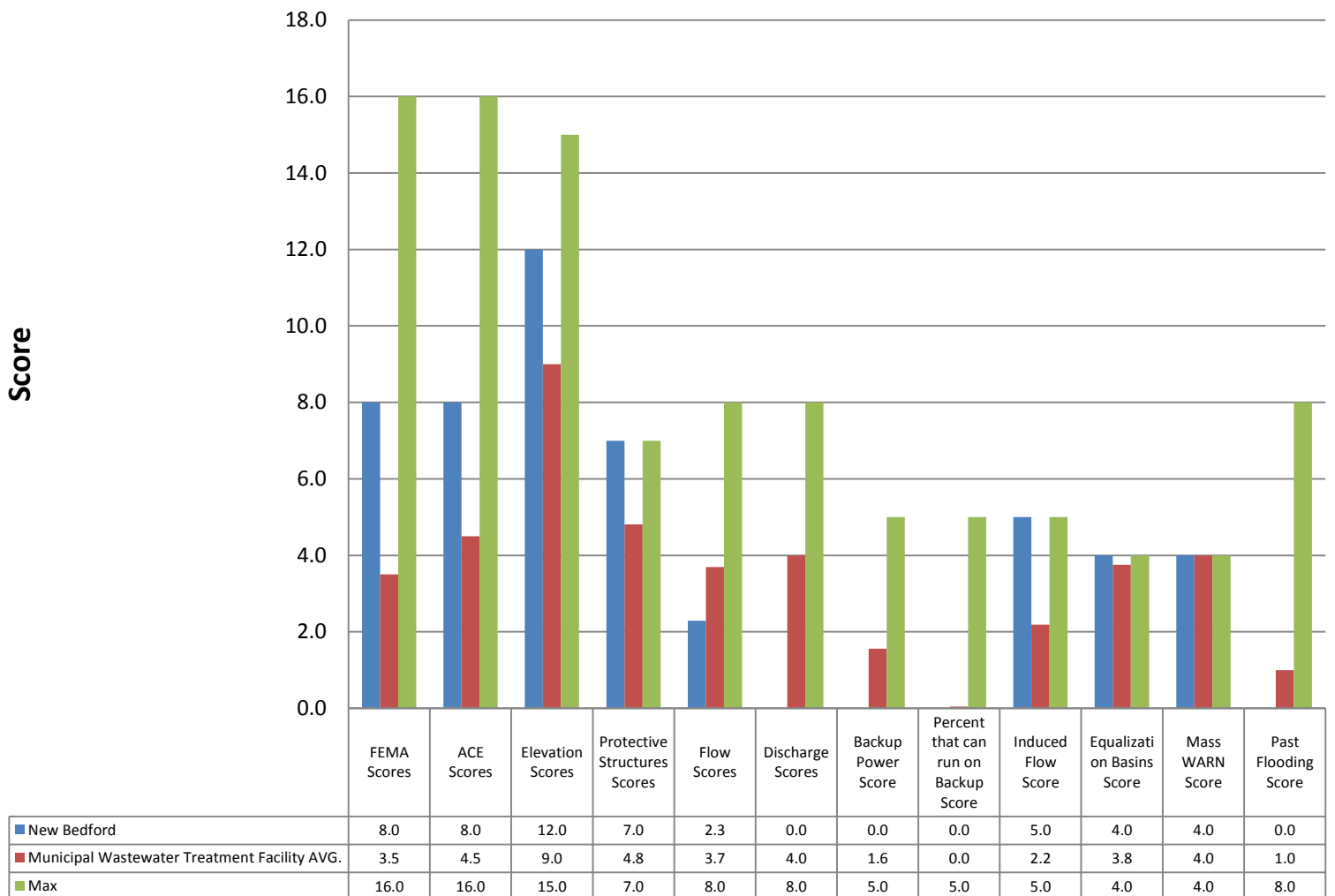
## Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

## Flood Risk Scores

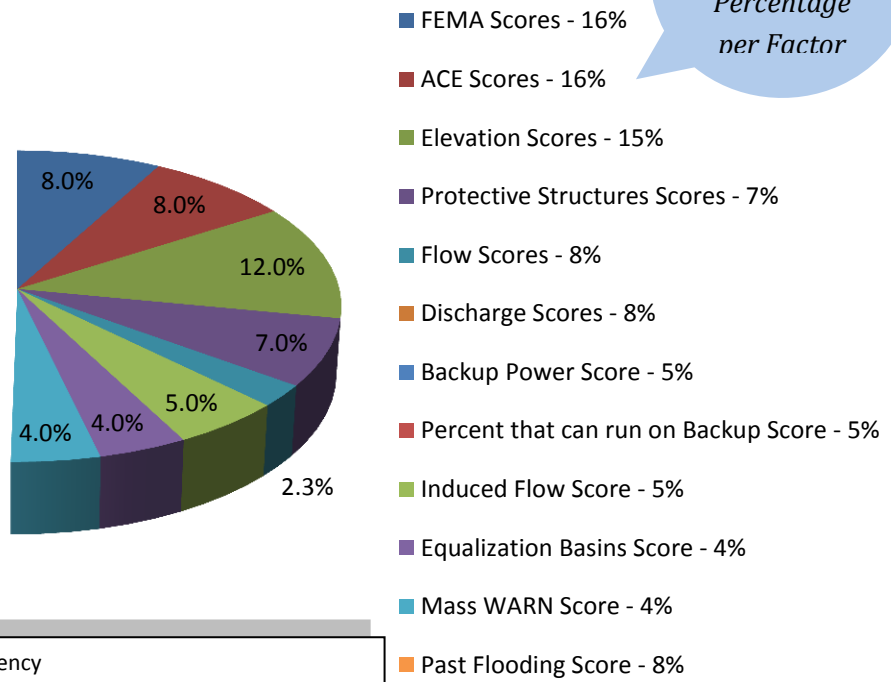
The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

### Flood Risk Assessment - New Bedford



# New Bedford

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility was found to be in a FEMA Flood Zone, and ACE Hurricane Inundation Zone which make up a significant portion of your risk level. Although your facility only ranked at a medium level, there are still actions that may be taken to decrease the facility's risk of flooding.

## Potential to decrease Risk Level:

- Become a member of Mass WARN

## **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Oak Bluffs Wastewater Treatment Facility

**MEDIUM: 37.6/100**

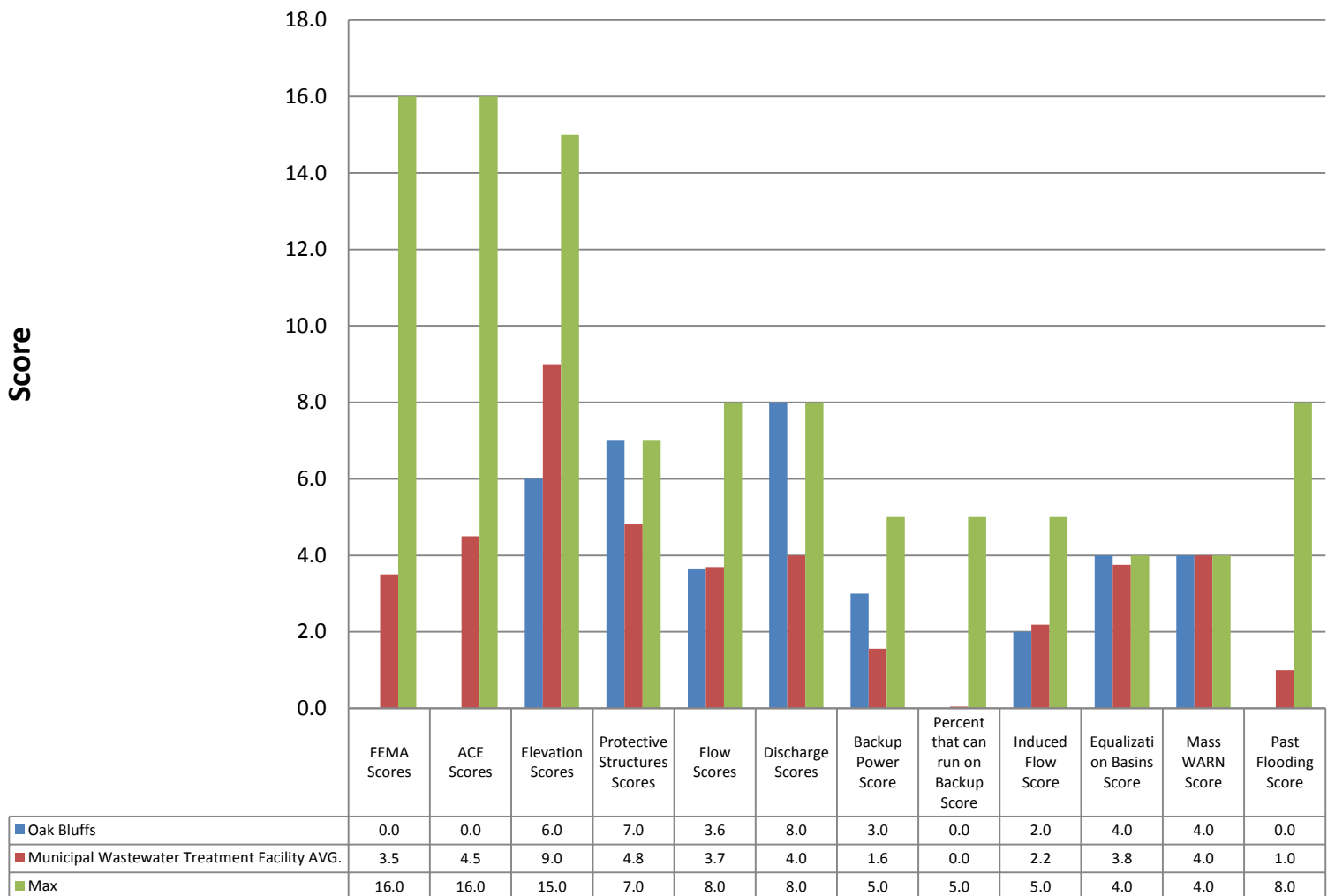
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

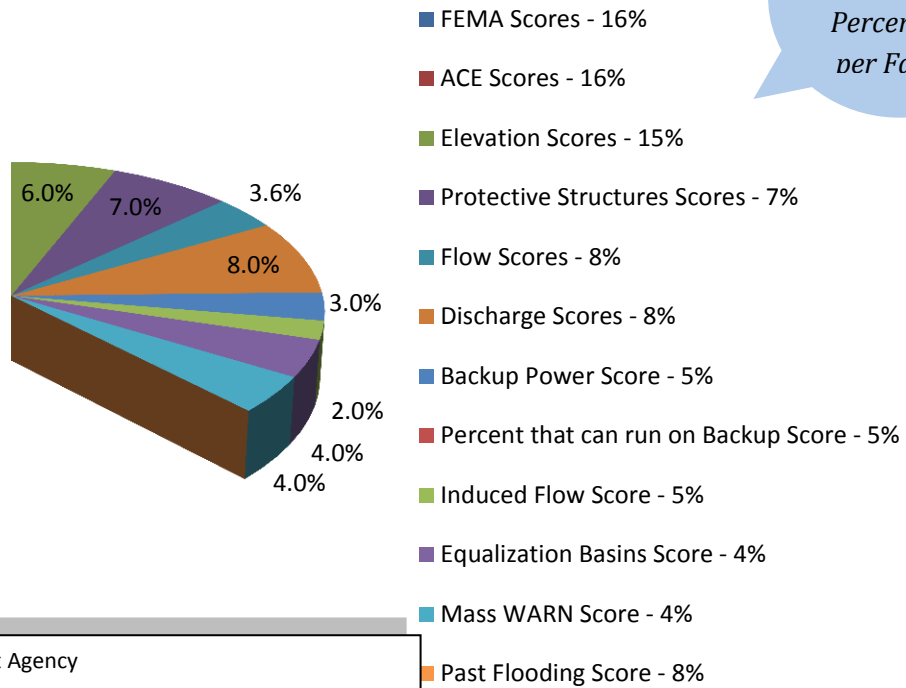
The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

## Flood Risk Assessment - Oak Bluffs



# Oak Bluffs

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility was not found to be in any FEMA Flood Zone, or ACE Hurricane Inundation Zones which are the two factors that carry the most weight in the tool. Although your facility only ranked at a medium level, there are still actions that may be taken to decrease the facility’s risk of flooding.

## Potential to decrease Risk Level:

- Become a member of Mass WARN
- Create Protective structures

## **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Plymouth Wastewater Treatment Facility

**LOW: 33/100**

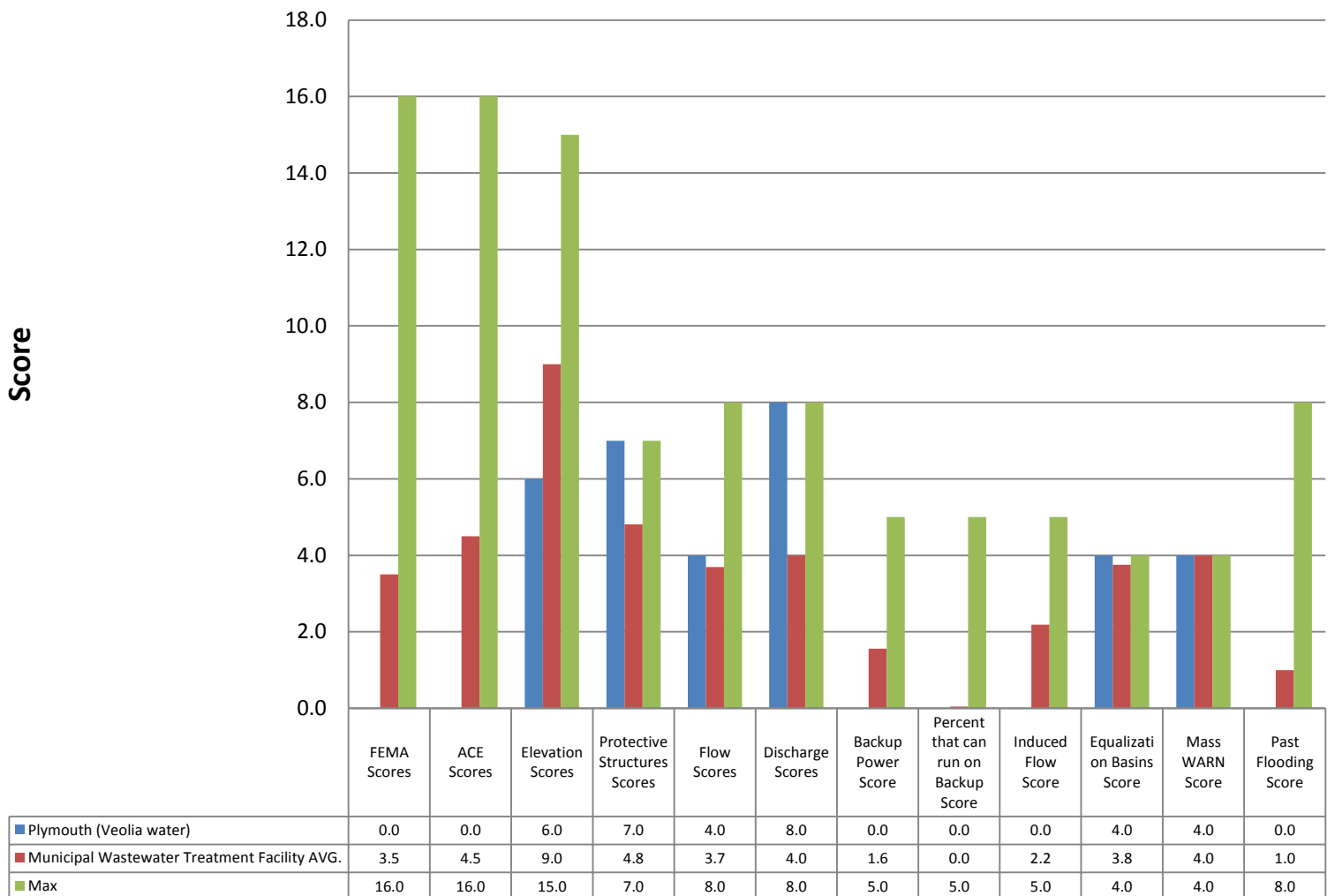
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

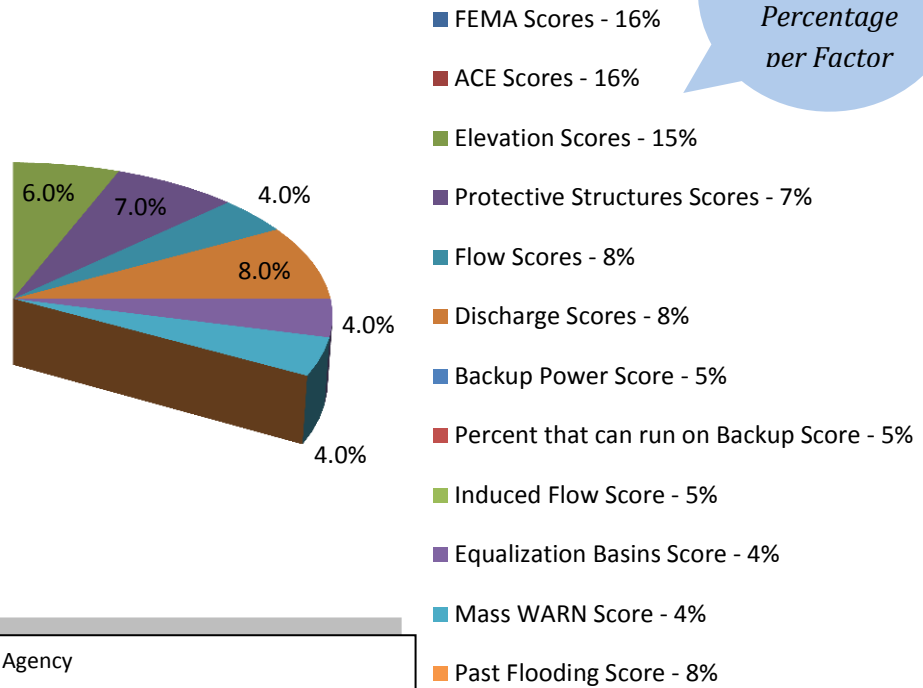
The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

## Flood Risk Assessment - Plymouth (Veolia Water)



# Plymouth (Veolia water)

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility is at a low flood risk, you do not fall into any FEMA Flood Zones or ACE Hurricane Inundation areas which are the two most heavily weighted factors. However here are some measures to take to further decrease your flood risk level:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Create Protective Structures

### **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with US EPA and Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected in 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Salisbury Wastewater Treatment Facility

**MEDIUM: 33.6/100**

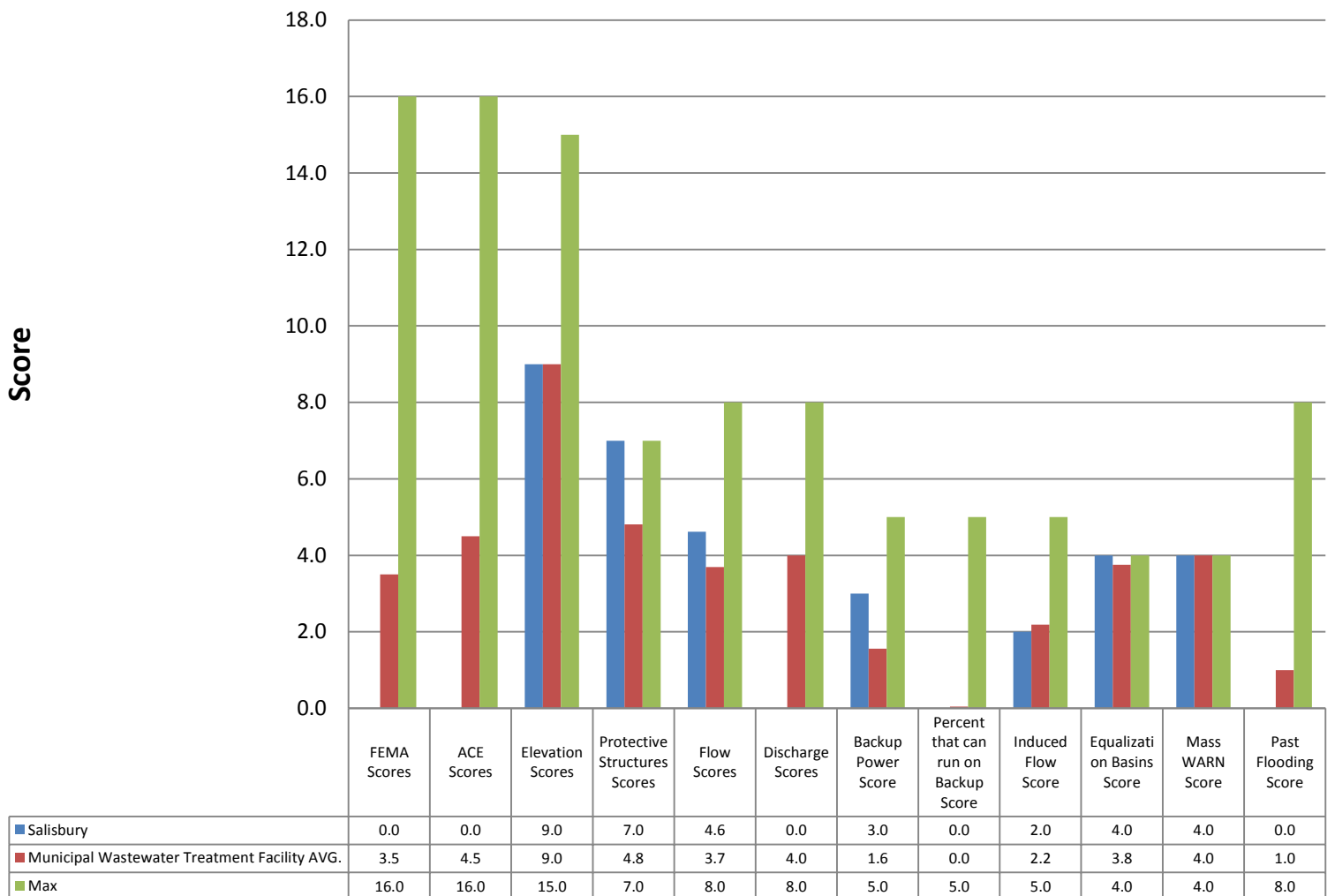
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

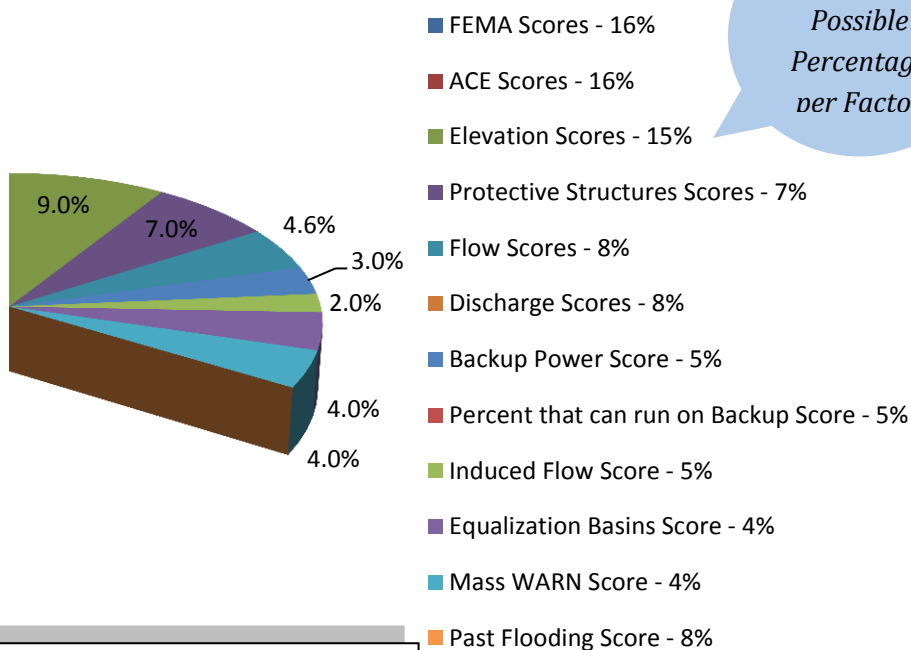
### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

## Flood Risk Assessment - Salisbury



# Salisbury



FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility was not found to be in any FEMA Flood Zone, or ACE Hurricane Inundation Zones which are the two factors that carry the most weight in the tool. Although your facility only ranked at a medium level, there are still actions that may be taken to decrease the facility's risk of flooding.

## Potential to decrease Risk Level:

- Become a member of Mass WARN
- Create Protective structures

## **For More Information:**

Alan Slater

Alan.slater@state.ma.us

617-292-5749



# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Pinewoods Camp Drinking Water Treatment Facility

**LOW: 20/100**

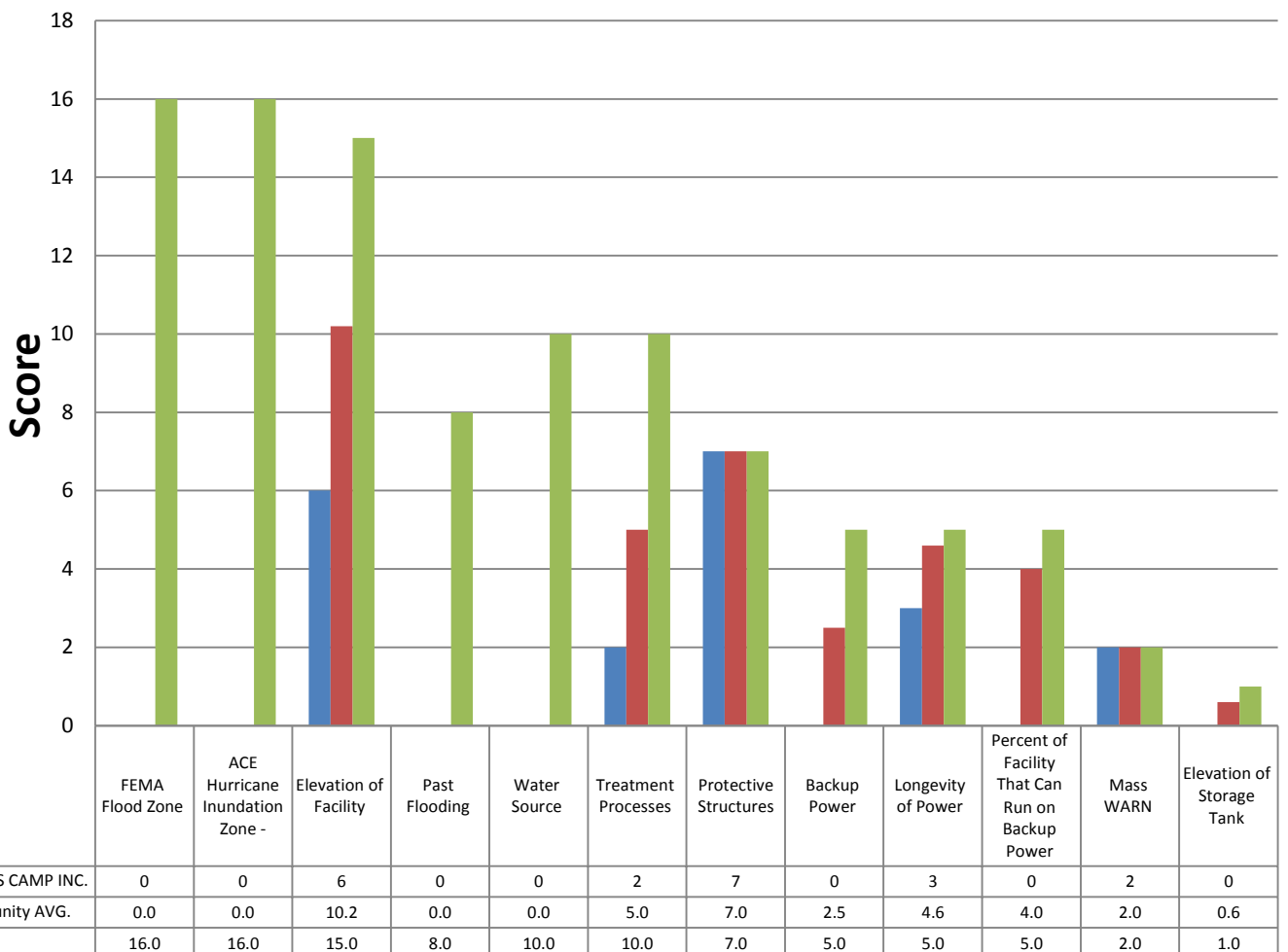
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal drinking water treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

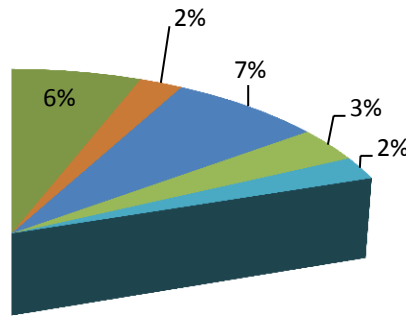
## Flood Risk Assessment - Pinewoods Camp Inc.



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# PINEWOODS CAMP INC.

*Maximum Possible Percentage per Factor*



- FEMA Flood Zone - 16%
- ACE Hurricane Inundation Zone - 16%
- Elevation of Facility - 15%
- Past Flooding - 8%
- Water Source - 10%
- Treatment Processes - 10%
- Protective Structures - 7%
- Backup Power - 5%
- Longevity of Power - 5%
- Percent of Facility That Can Run on Backup Power - 5%
- Mass WARN - 2%
- Elevation of Storage Tank - 1%

FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## **Resources and Assistance Available for Flood Resiliency Measures:**

Your facility is at a low flood risk, you do not fall into any FEMA Flood Zones, or ACE Hurricane Inundation areas. Here are some measures to take to further decrease your flood risk level:

### **Potential to decrease Risk Level:**

- Become a member of Mass WARN
- Create Protective Structures
- Increase longevity of backup power

### **For More Information:**

Paul Niman,

[Paul.niman@state.ma.us](mailto:Paul.niman@state.ma.us)

617-556-1166

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at Westport Seatoller Treatment Facility

**MEDIUM: 47/100**

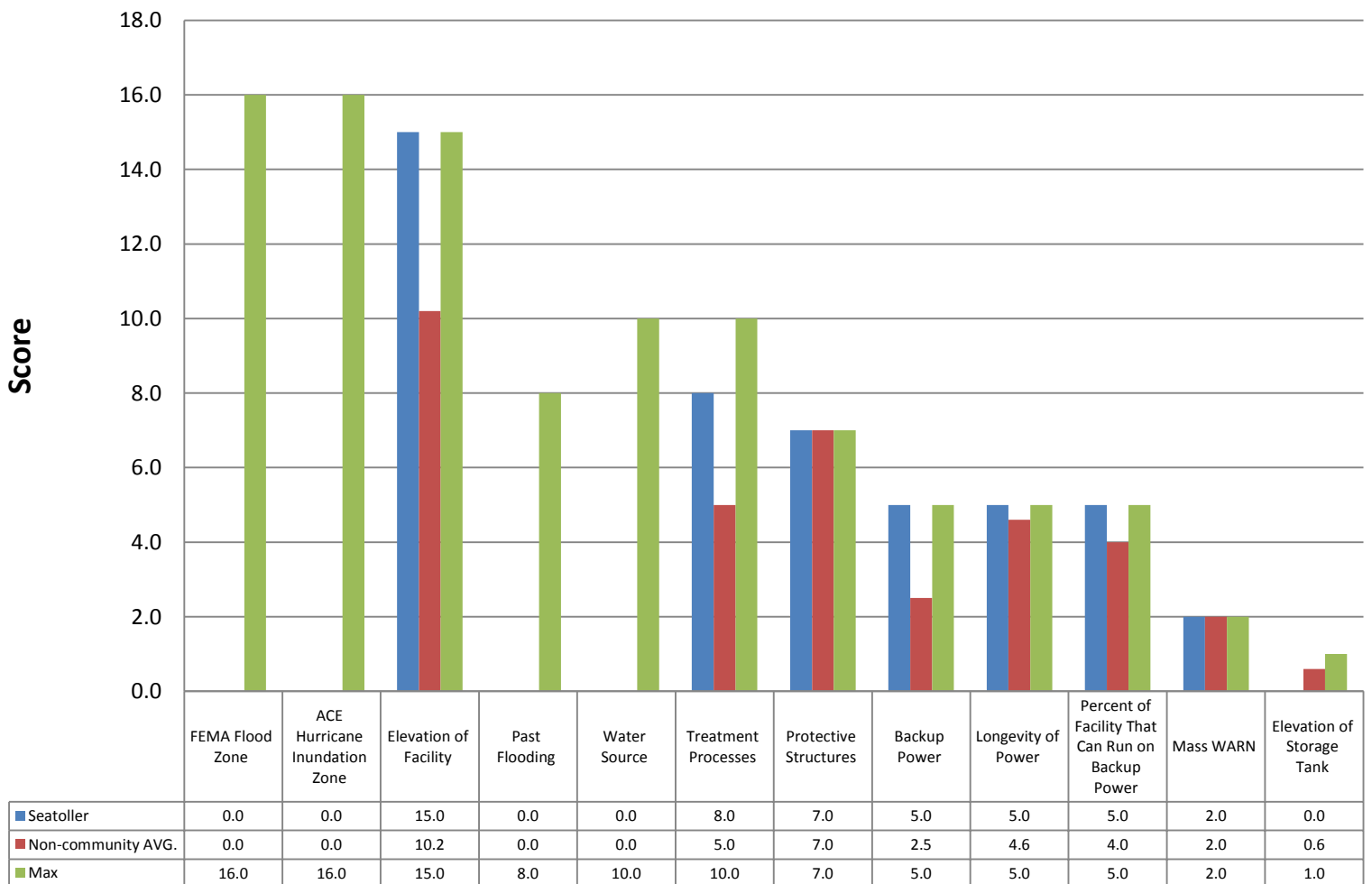
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal drinking water treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist drinking water treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

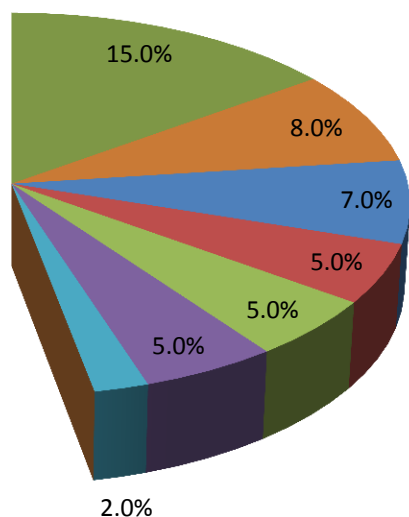
## Flood Risk Assessment – Seatoller



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Seatoller

*Maximum Possible Percentage per Factor*



- FEMA Flood Zone - 16%
- ACE Hurricane Inundation Zone - 16%
- Elevation of Facility - 15%
- Past Flooding - 8%
- Water Source - 10%
- Treatment Processes - 10%
- Protective Structures - 7%
- Backup Power - 5%
- Longevity of Power - 5%
- Percent of Facility That Can Run on Backup Power - 5%
- Mass WARN - 2%
- Elevation of Storage Tank - 1%

FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

### Resources and Assistance Available for Flood Resiliency Measures:

Your facility was not found to be in any FEMA Flood Zone, or ACE Hurricane Inundation Zones. Your facility was found to be at a medium risk for flooding. Although your facility only ranked at a medium level, there are still actions that may be taken to decrease the facility's risk of flooding.

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Install Protective Structures
- Install Backup Power, that will run a majority of your processes

### **For More Information:**

Paul Niman,  
[Paul.niman@state.ma.us](mailto:Paul.niman@state.ma.us)  
 617-556-1166

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the New Testament Church Drinking Water Treatment Facility

**LOW: 33/100**

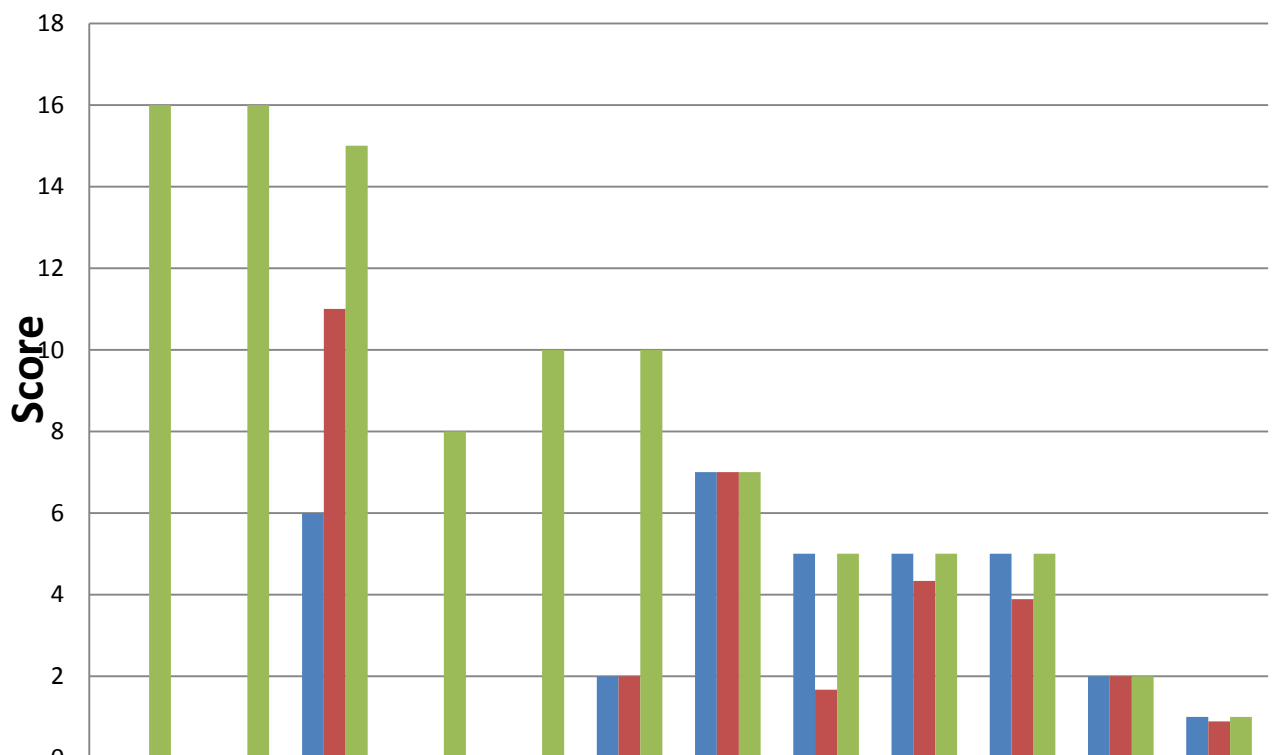
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

## Flood Risk Assessment - New Testament Church



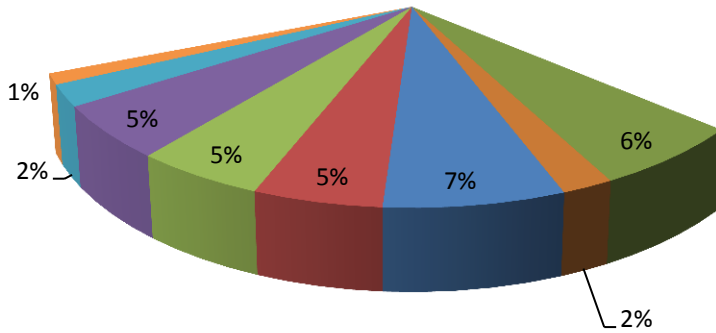
■ THE NEW TESTAMENT CHURCH  
 ■ Non-community Transient AVG.  
 ■ Max

\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# THE NEW TESTAMENT CHURCH

*Maximum Possible Percentage per Factor*

- FEMA Flood Zone - 16%
- ACE Hurricane Inundation Zone - 16%
- Elevation of Facility - 15%
- Past Flooding - 8%
- Water Source - 10%
- Treatment Processes - 10%
- Protective Structures - 7%
- Backup Power - 5%
- Longevity of Power - 5%
- Percent of Facility That Can Run on Backup Power - 5%
- Mass WARN - 2%
- Elevation of Storage Tank - 1%



FEMA: Federal Emergency Management Agency  
 ACE: Army Core of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility is at a low flood risk, you do not fall into any FEMA Flood Zones, or ACE Hurricane Inundation areas. Here are some measures to take to further decrease your flood risk level:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Raise storage tanks
- Create Protective Structures
- Install Backup Power
- Develop a method to increase percentage of facility that is operational on backup power

### **For More Information:**

Paul Niman,  
[Paul.niman@state.ma.us](mailto:Paul.niman@state.ma.us)  
 617-556-1166

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at Westport Plymouth South High School Treatment Facility

**LOW: 16/100**

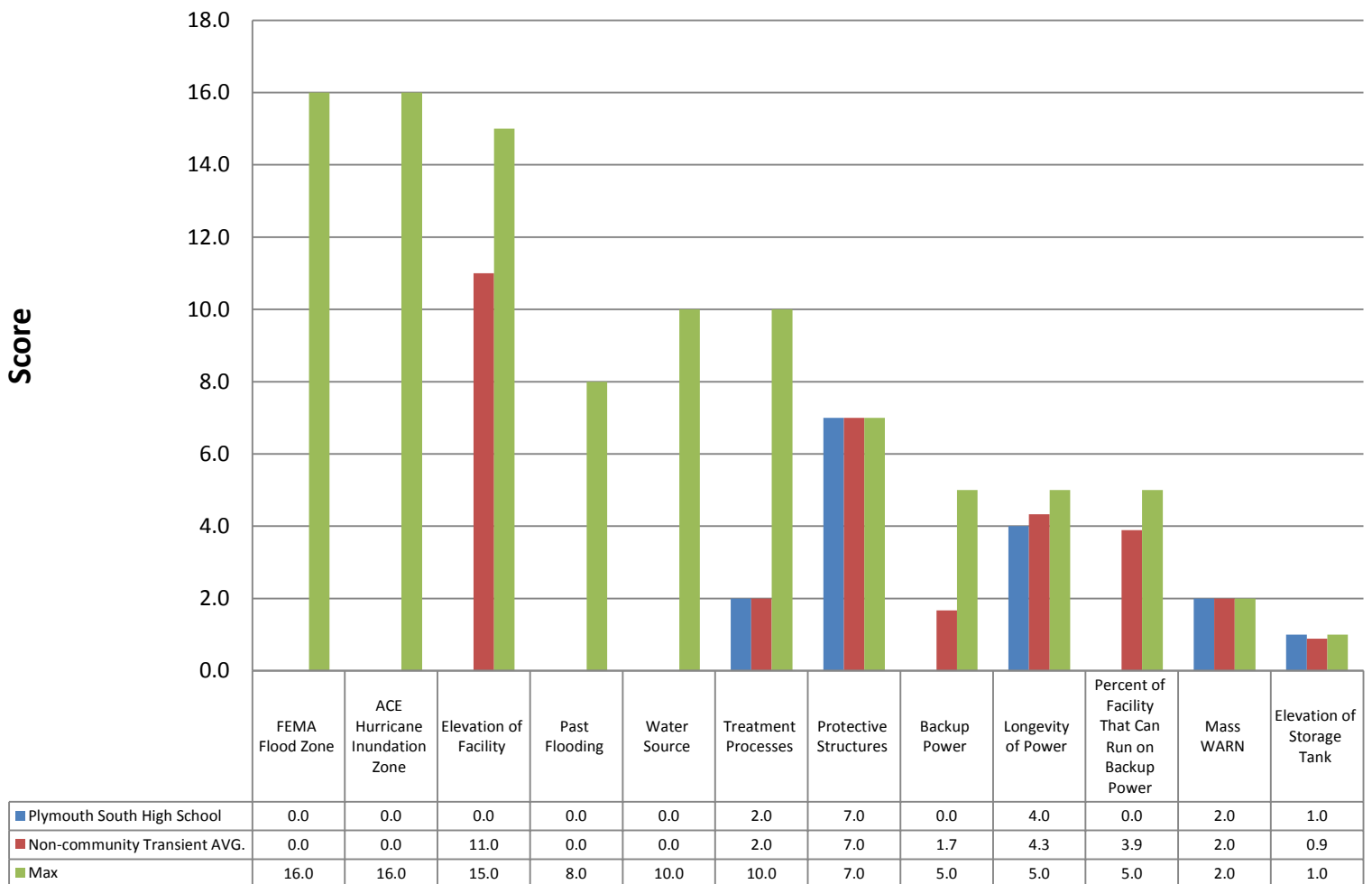
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal drinking water treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist drinking water treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

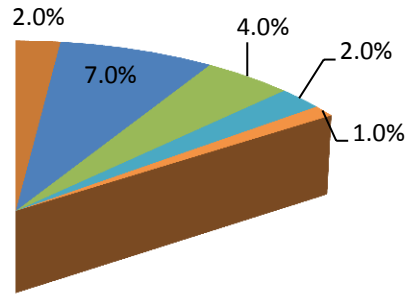
## Flood Risk Assessment – Plymouth South High School



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Plymouth South High School

*Maximum Possible Percentage per Factor*



- FEMA Flood Zone - 16%
- ACE Hurricane Inundation Zone - 16%
- Elevation of Facility - 15%
- Past Flooding - 8%
- Water Source - 10%
- Treatment Processes - 10%
- Protective Structures - 7%
- Backup Power - 5%
- Longevity of Power - 5%
- Percent of Facility That Can Run on Backup Power - 5%
- Mass WARN - 2%
- Elevation of Storage Tank - 1%

FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## **Resources and Assistance Available for Flood Resiliency Measures:**

Your facility is at a low flood risk, you do not fall into any FEMA Flood Zones, or ACE Hurricane Inundation areas. However here are some measures to take to further decrease your flood risk level:

### **Potential to decrease Risk Level:**

- Become a member of Mass WARN
- Install Protective Structures
- Install Backup Power, that will run a majority of your processes

### **For More Information:**

Paul Niman,  
[Paul.niman@state.ma.us](mailto:Paul.niman@state.ma.us)  
 617-556-166



# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at The Baird Center Treatment Facility

**LOW: 20/100**

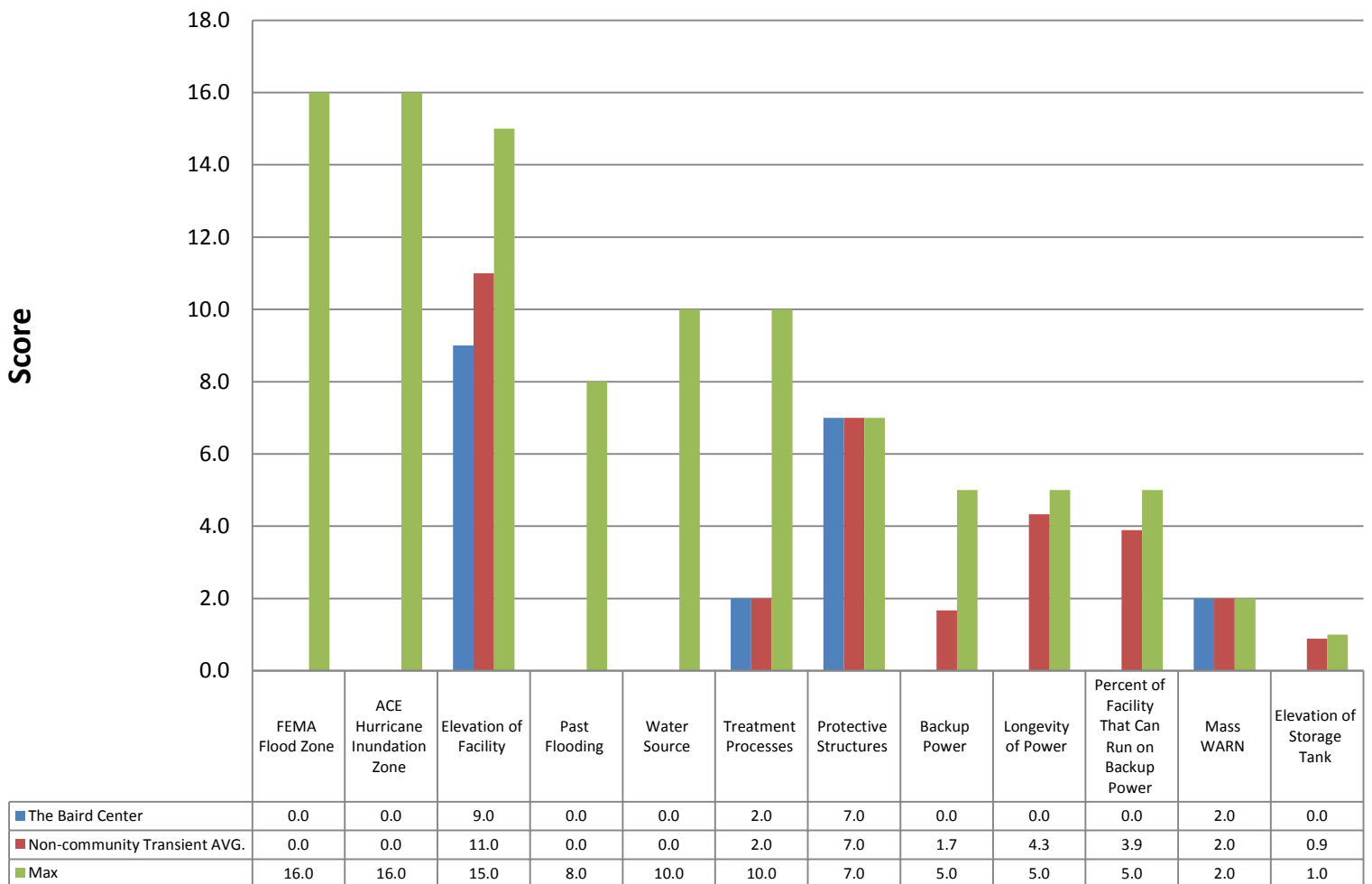
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal drinking water treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist drinking water treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

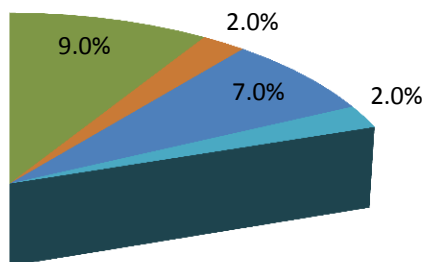
## Flood Risk Assessment – The Baird Center



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# The Baird Center

*Maximum Possible Percentage per Factor*



- FEMA Flood Zone - 16%
- ACE Hurricane Inundation Zone - 16%
- Elevation of Facility - 15%
- Past Flooding - 8%
- Water Source - 10%
- Treatment Processes - 10%
- Protective Structures - 7%
- Backup Power - 5%
- Longevity of Power - 5%
- Percent of Facility That Can Run on Backup Power - 5%
- Mass WARN - 2%
- Elevation of Storage Tank - 1%

FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility is at a low flood risk, you do not fall into any FEMA Flood Zones, or ACE Hurricane Inundation areas. However here are some measures to take to further decrease your flood risk level:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Install Protective Structures
- Install Backup Power, that will run a majority of your processes

### **For More Information:**

Paul Niman,

[Paul.niman@state.ma.us](mailto:Paul.niman@state.ma.us)

617-556-1166

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found [here](#).

## Flood Risk Score at the Automatic Coin Laundry Wastewater Treatment Facility

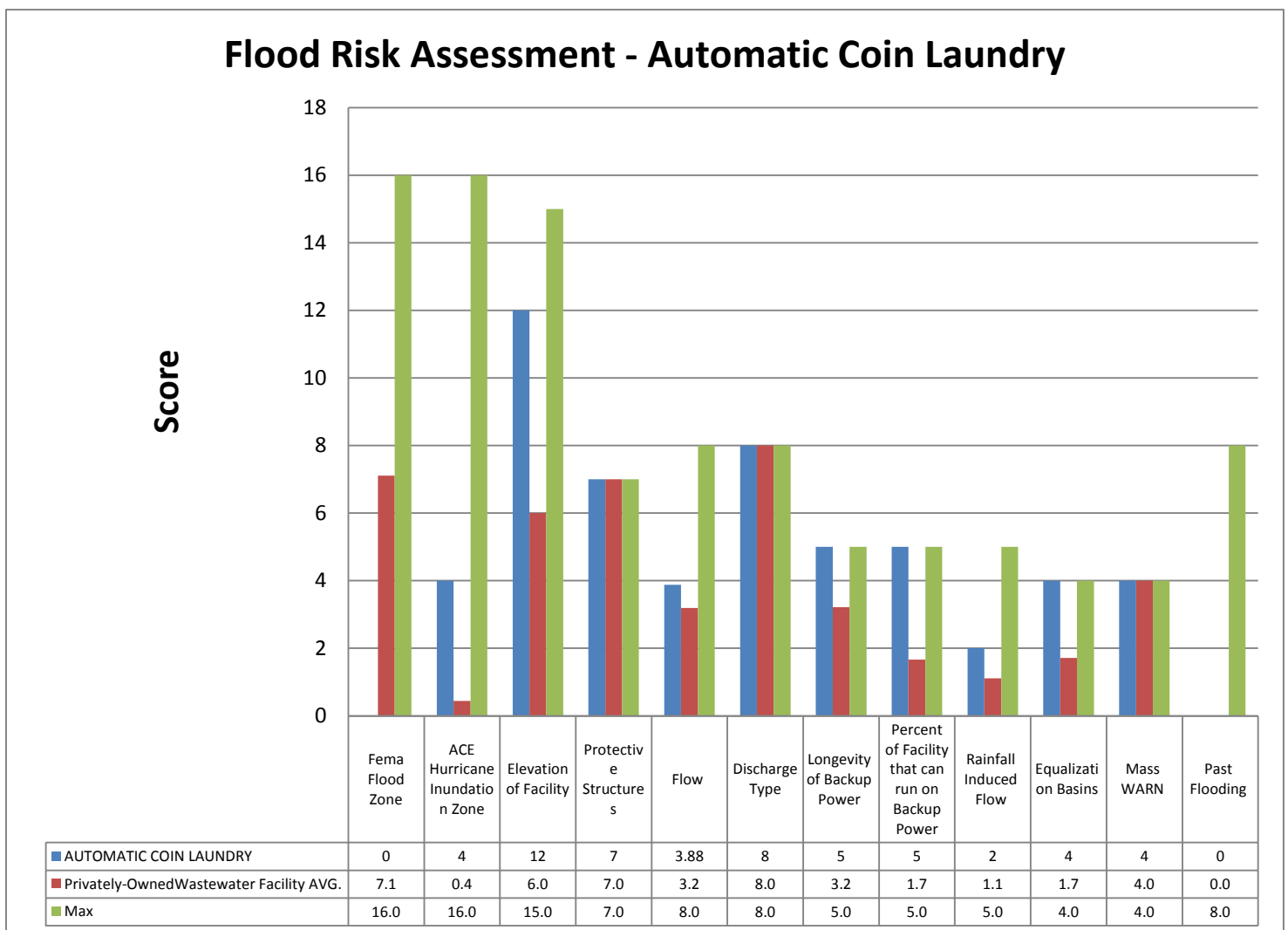
**MEDIUM: 54.88/100**

### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

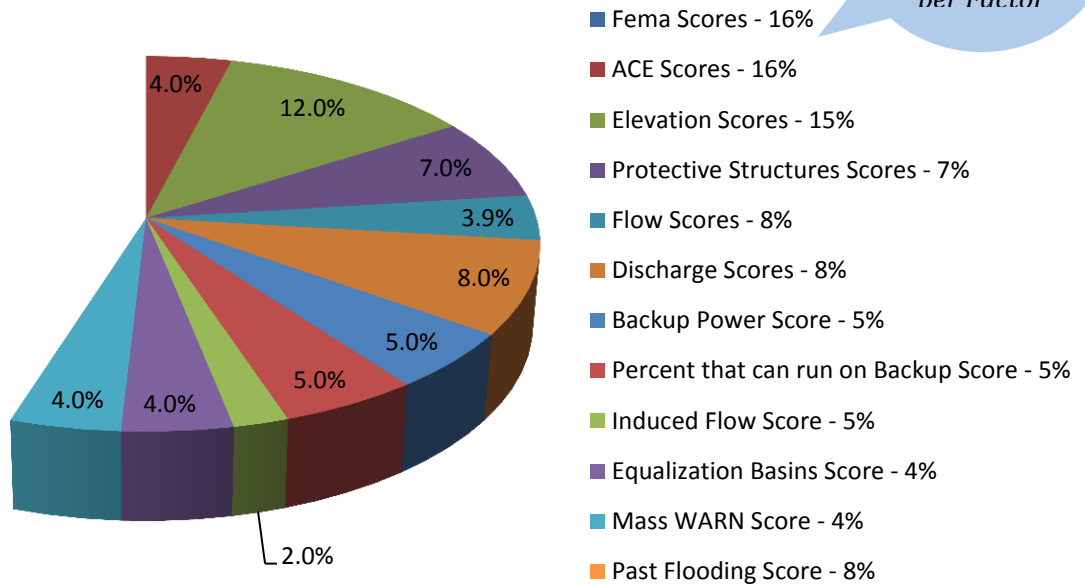
The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# AUTOMATIC COIN LAUNDRY

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility was not found to be in any FEMA Flood Zone, and ranked in one of the 4 categories when it came to observing the ACE categories. However your facility did rank at a medium level for flooding; here are some areas where you may improve your score:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Install Protective Structures
- Install Backup Power, that will run a majority of your processes

### **For More Information:**

Alan Slater  
[Alan.Slater@state.ma.us](mailto:Alan.Slater@state.ma.us)

617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Black Rock Golf Community Wastewater Treatment Facility

**MEDIUM: 47.6/100**

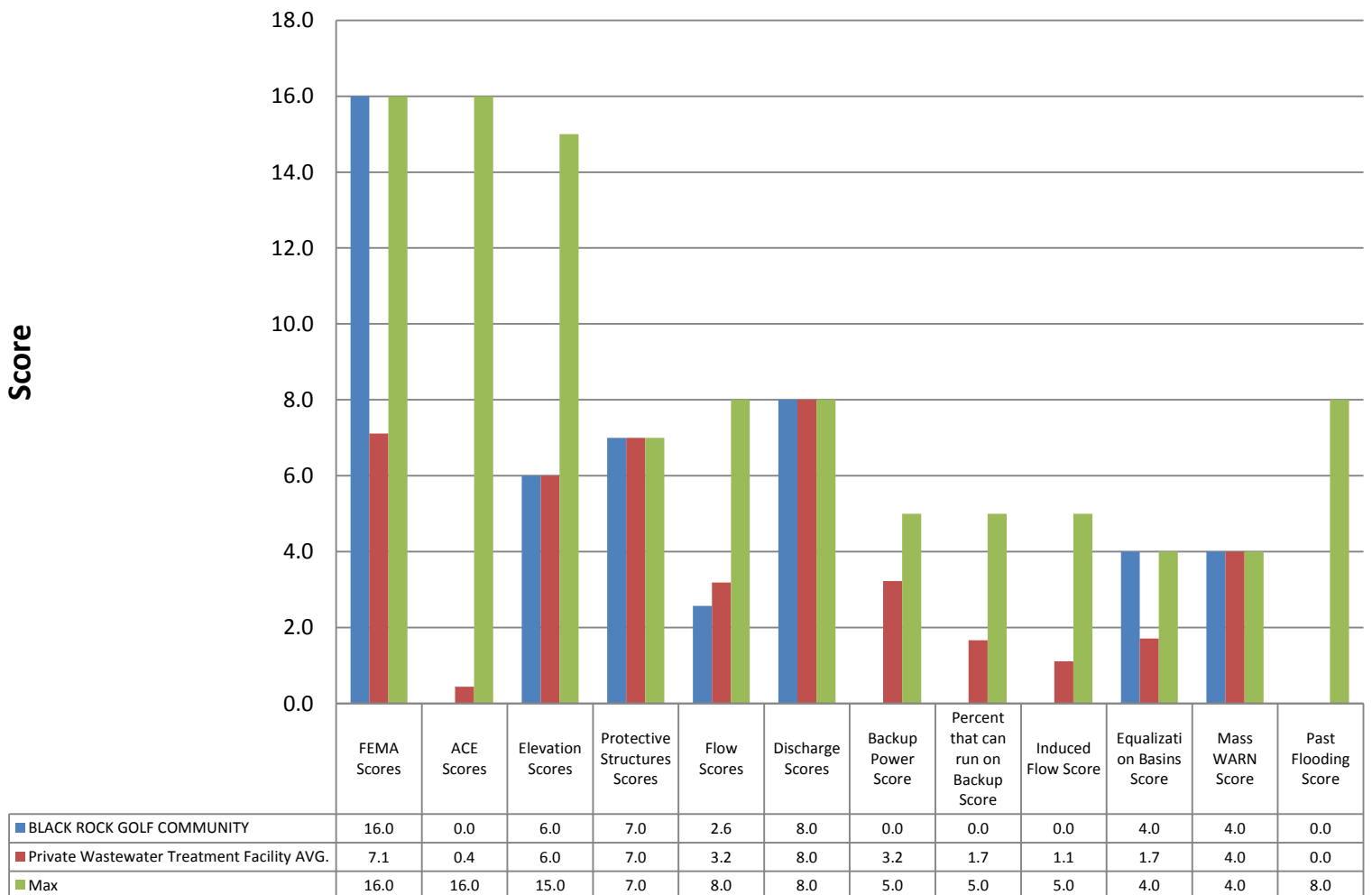
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

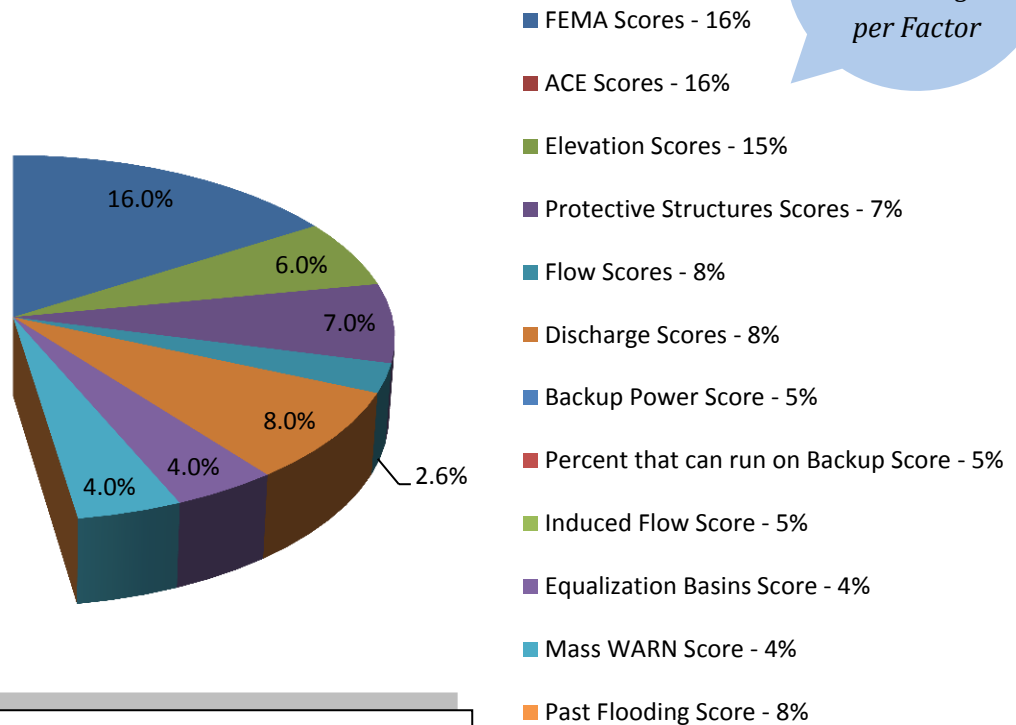
## Flood Risk Assessment – Black Rock Golf Community



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Black Rock Golf Community

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility was found to be in a FEMA Flood Zone, which is one of the more heavily weighted factors. Your facility did not rank in one of the 4 categories when it came to observing the ACE categories. However your facility did rank at a medium level for flooding; here are some areas where you may improve your score:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Install Protective Structures

### **For More Information:**

Alan Slater  
[Alan.Slater@state.ma.us](mailto:Alan.Slater@state.ma.us)  
 617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at Linden Ponds at Hingham Wastewater Treatment Facility

**MEDIUM: 48.4/100**

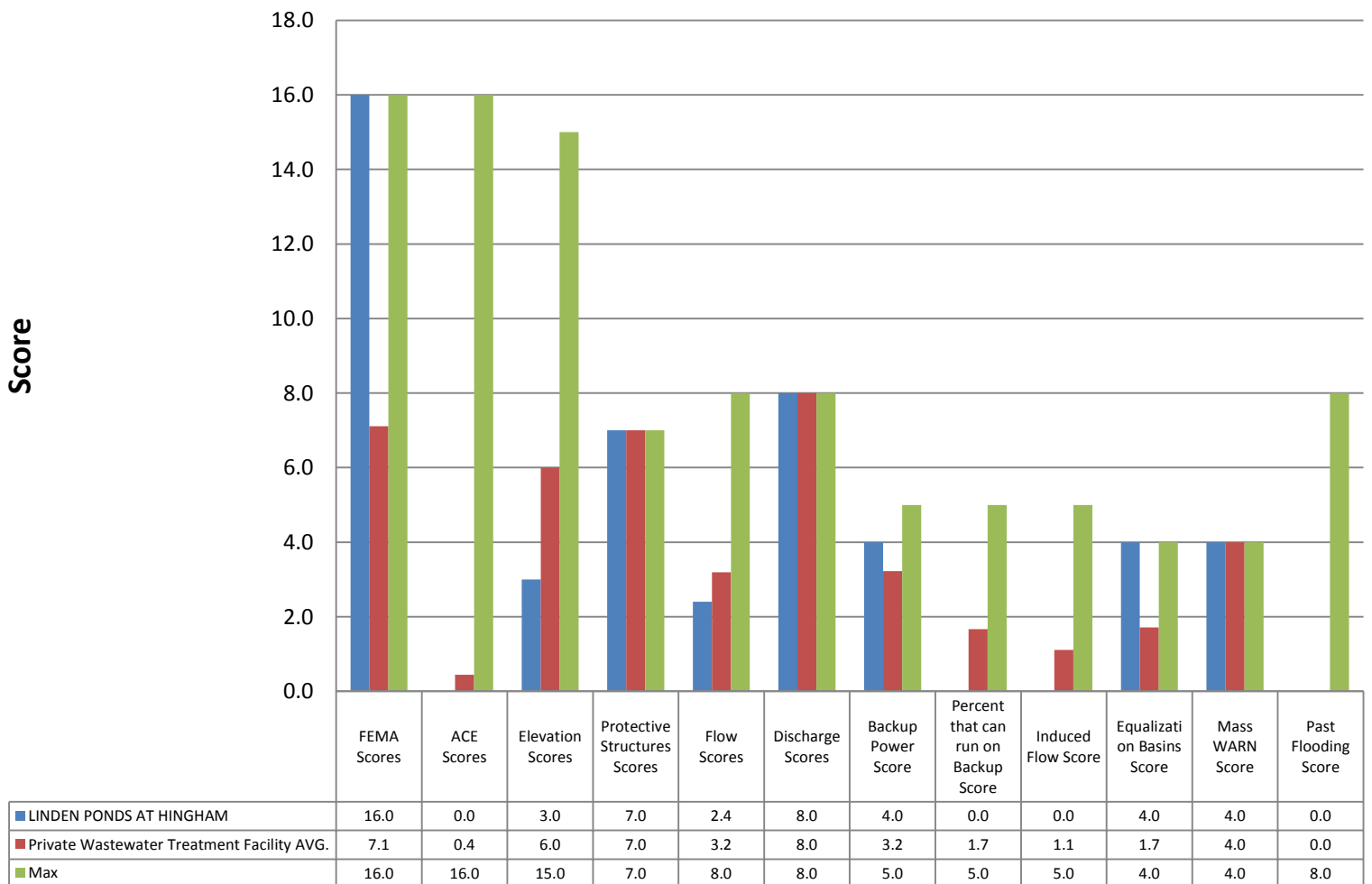
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

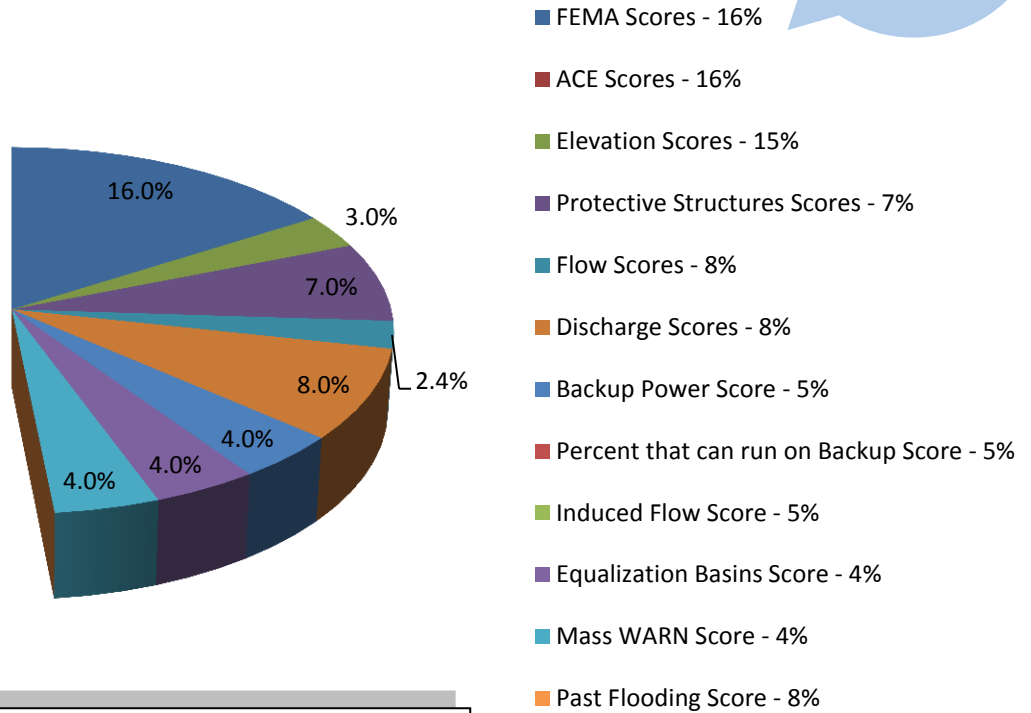
## Flood Risk Assessment – Linden Ponds at Hingham



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# LINDEN PONDS AT HINGHAM

Maximum Possible Percentage per Factor



FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility was found to be in a FEMA Flood Zone, which is one of the more heavily weighted factors. Your facility did not rank in 1 of the 4 categories when it came to observing the ACE categories. However your facility did rank at a medium level for flooding; here are some areas where you may improve your score:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Install Protective Structures

### **For More Information:**

Alan Slater  
[Alan.Slater@state.ma.us](mailto:Alan.Slater@state.ma.us)  
 617-292-5749



# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at the Pilgrim Power Station Wastewater Treatment Facility

**MEDIUM: 51.9/100**

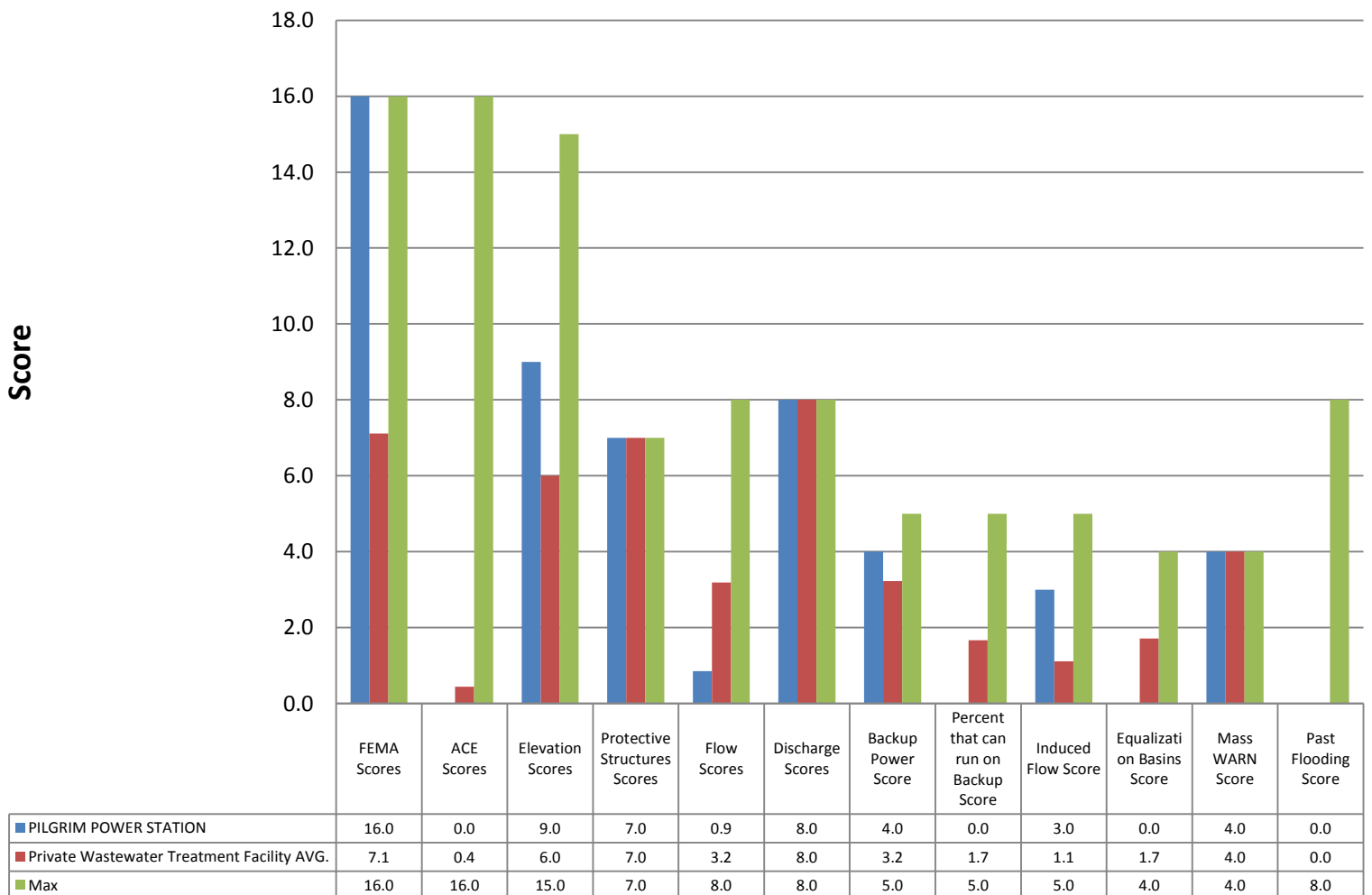
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

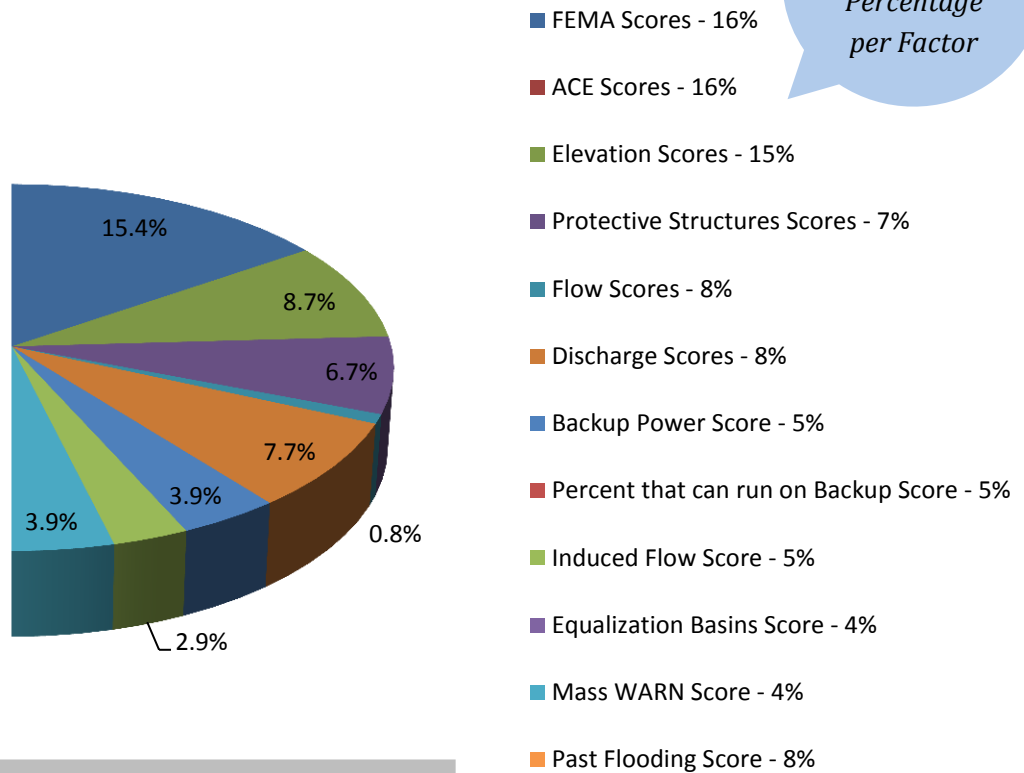
## Flood Risk Assessment – Pilgrim Power Station



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Pilgrim Power Station

*Maximum Possible Percentage per Factor*



FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility was found to be in a FEMA Flood Zone, which is one of the more heavily weighted factors. Your facility did not rank in 1 of the 4 categories when it came to observing the ACE categories. However your facility did rank at a medium level for flooding; here are some areas where you may improve your score:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Install Protective Structures
- Install Backup Power, that will run a majority of your processes

### For More Information:

Alan Slater  
[Alan.Slater@state.ma.us](mailto:Alan.Slater@state.ma.us)  
 617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at Plymouth South High School Treatment Facility

**LOW: 29/100**

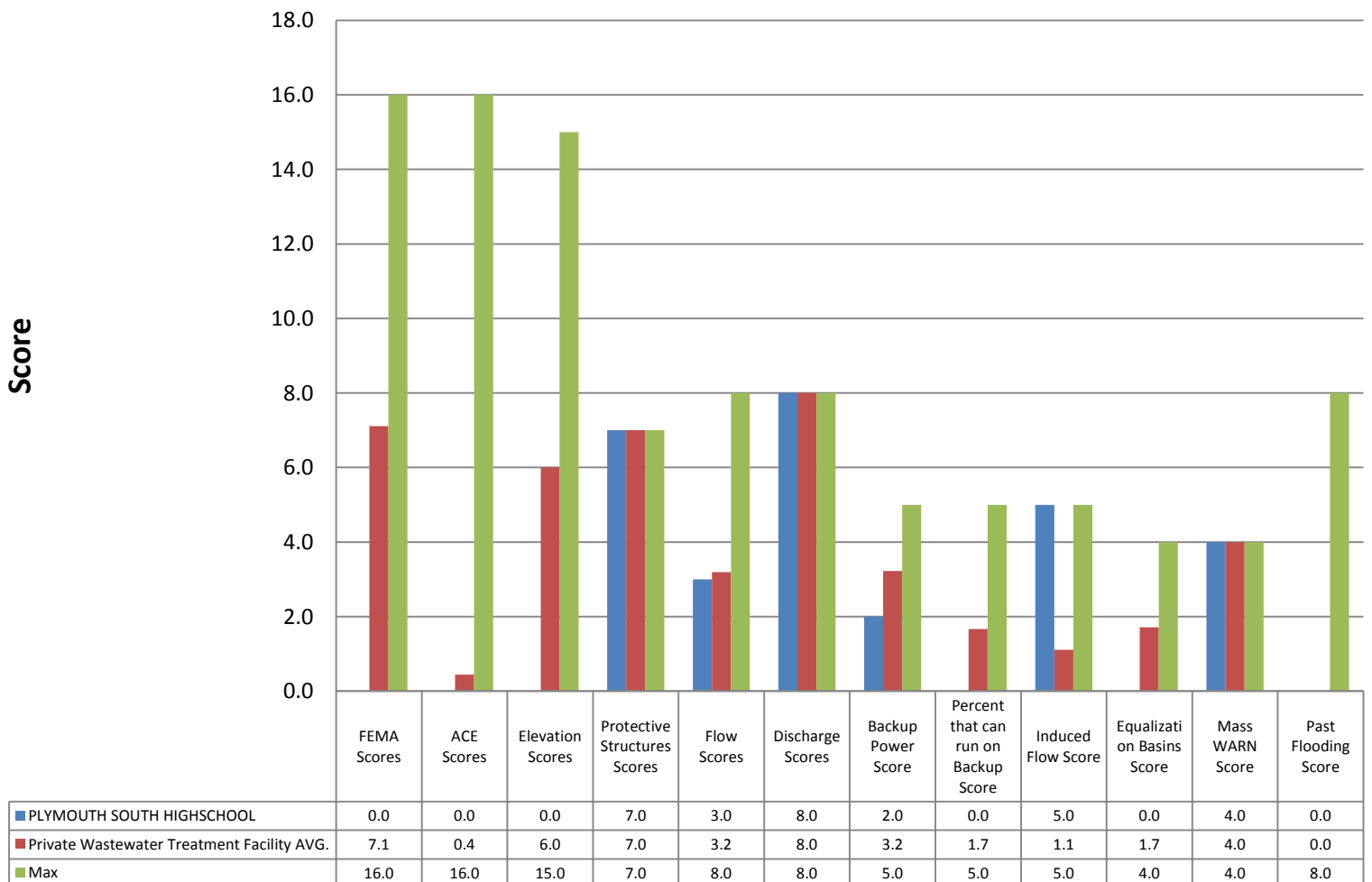
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

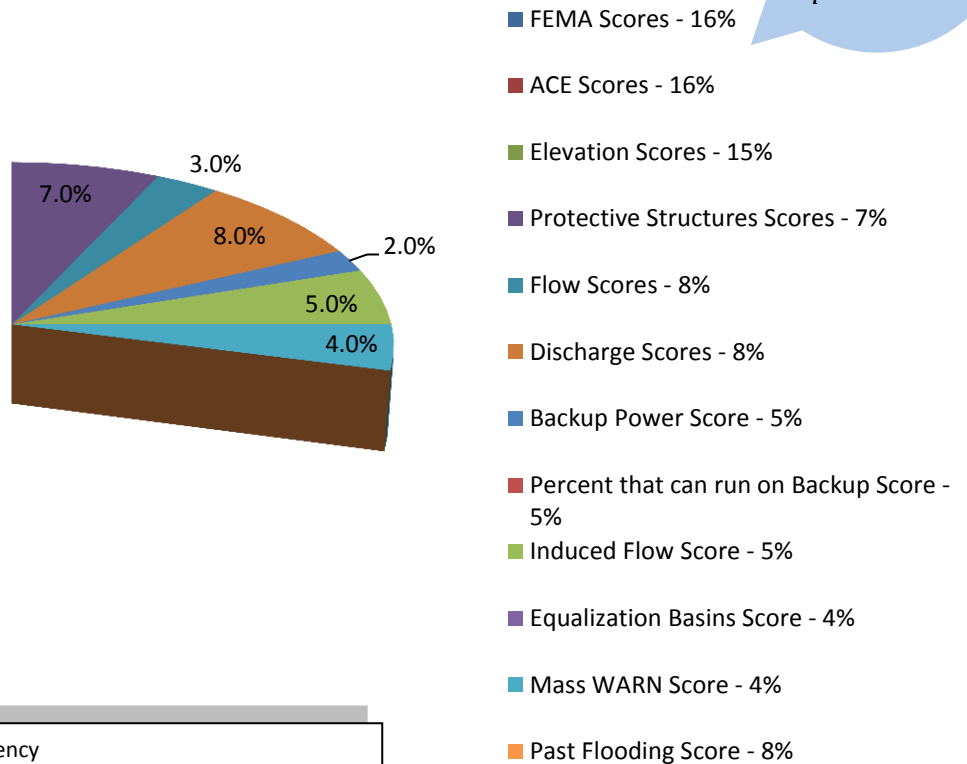
## Flood Risk Assessment – Plymouth South High School



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Plymouth South High School

Maximum Possible Percentage per Factor



FEMA: Federal Emergency Management Agency  
 ACE: Army Corps of Engineers  
 Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## **Resources and Assistance Available for Flood Resiliency Measures:**

Your facility is at a low flood risk, you do not fall into any FEMA Flood Zones or ACE Hurricane Inundation areas which are the two most heavily weighted factors. However here are some measures to take to further decrease your flood risk level:

### **Potential to decrease Risk Level:**

- Become a member of Mass WARN
- Install Protective Structures

### **For More Information:**

Alan Slater  
[Alan.Slater@state.ma.us](mailto:Alan.Slater@state.ma.us)  
 617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found [here](#).

## Flood Risk Score at Spyglass Landing Treatment Facility

**LOW: 25.1/100**

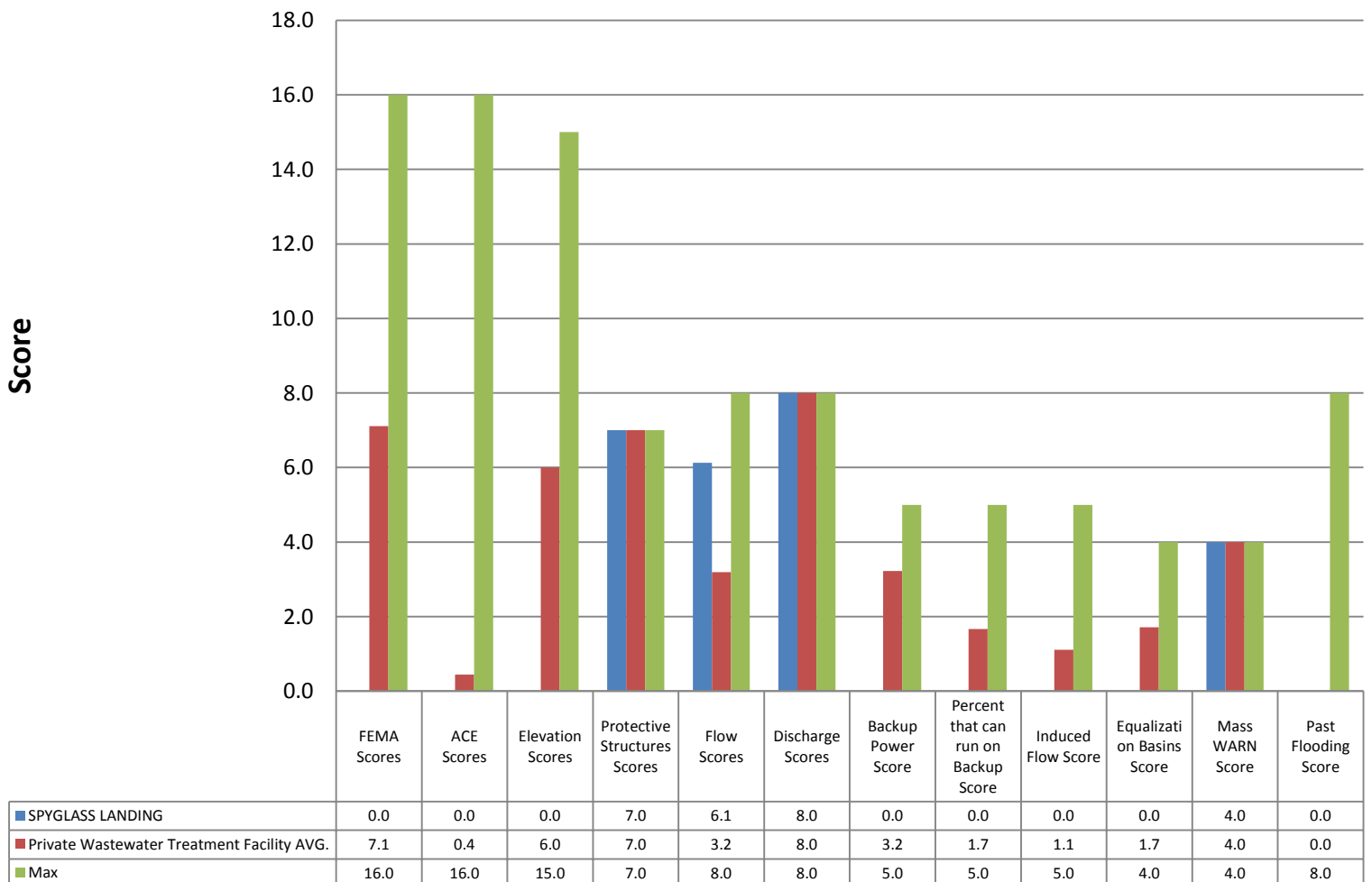
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

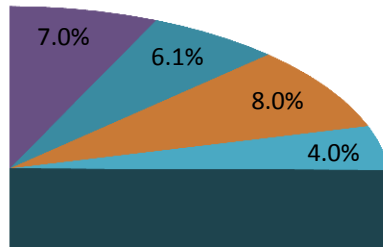
## Flood Risk Assessment – Spyglass Landing



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# Spyglass Landing

Maximum  
Possible  
Percentage  
per Factor



- FEMA Scores - 16%
- ACE Scores - 16%
- Elevation Scores - 15%
- Protective Structures Scores - 7%
- Flow Scores - 8%
- Discharge Scores - 8%
- Backup Power Score - 5%
- Percent that can run on Backup Score - 5%
- Induced Flow Score - 5%
- Equalization Basins Score - 4%
- Mass WARN Score - 4%
- Past Flooding Score - 8%

FEMA: Federal Emergency Management Agency  
ACE: Army Corps of Engineers  
Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## **Resources and Assistance Available for Flood Resiliency Measures:**

Your facility is at a low flood risk, you do not fall into any FEMA Flood Zones or ACE Hurricane Inundation areas which are the two most heavily weighted factors. However here are some measures to take to further decrease your flood risk level:

### **Potential to decrease Risk Level:**

- Become a member of Mass WARN
- Install Protective Structures

### **For More Information:**

Alan Slater  
[Alan.Slater@state.ma.us](mailto:Alan.Slater@state.ma.us)  
617-292-5749

# Flood Risk Screening

MassDEP, in conjunction with Worcester Polytechnic Institute, conducted a preliminary screening of the flood risk at your facility. Based upon screening-level data collected 2011 and 2012, the summary of the flood risk level at your facility can be found here.

## Flood Risk Score at White Cliffs Condo Treatment Facility

**LOW: 29.5/100**

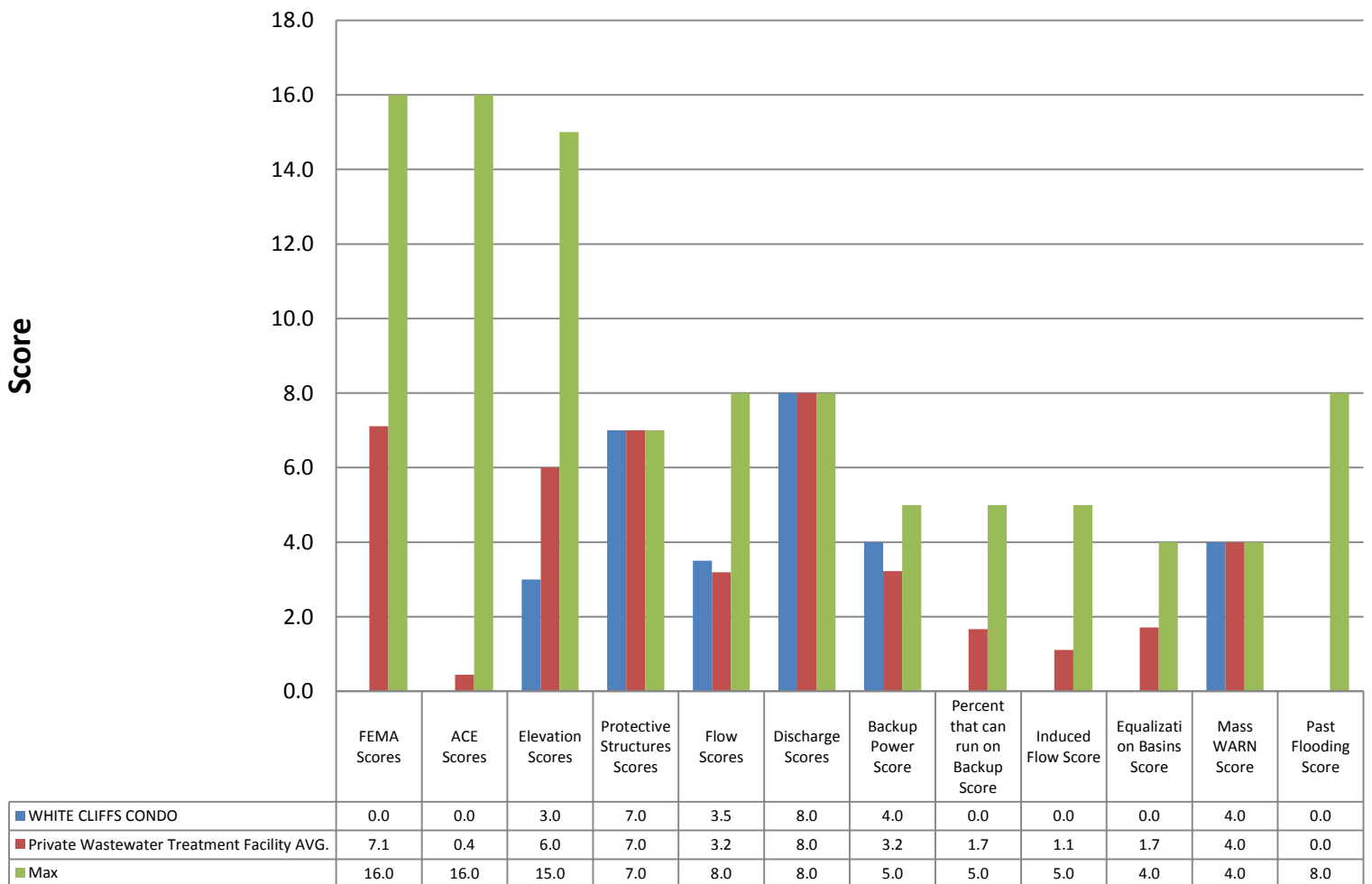
### Background

This flood risk screening is intended to provide a preliminary assessment of flood vulnerability at coastal wastewater treatment plants in Massachusetts. The risk-ranking (and the factors contributing to it) is intended to assist wastewater treatment facilities, and key decision-makers and stakeholders, in planning for future flood-resiliency actions.

### Flood Risk Scores

The “score” indicates the point value of each factor. A higher overall score or point value represents a higher level of risk. The maximum score a facility may receive is 100.

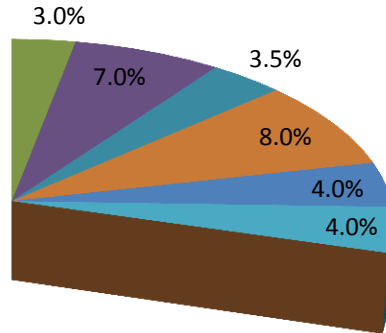
## Flood Risk Assessment – White Cliffs Condo



\*Backup Power and Longevity of Power data was collected from an EPA report in 2011; however through surveys the data was confirmed.

# White Cliffs Condo

Maximum Possible Percentage per Factor



- FEMA Scores - 16%
- ACE Scores - 16%
- Elevation Scores - 15%
- Protective Structures Scores - 7%
- Flow Scores - 8%
- Discharge Scores - 8%
- Backup Power Score - 5%
- Percent that can run on Backup Score - 5%
- Induced Flow Score - 5%
- Equalization Basins Score - 4%
- Mass WARN Score - 4%
- Past Flooding Score - 8%

FEMA: Federal Emergency Management Agency  
ACE: Army Corps of Engineers  
Mass WARN: Massachusetts Water and Wastewater Agency Response Network

\*A full pie chart indicates a facility at the greatest level of risk to flooding

## Resources and Assistance Available for Flood Resiliency Measures:

Your facility is at a low flood risk, you do not fall into any FEMA Flood Zones or ACE Hurricane Inundation areas which are the two most heavily weighted factors. However here are some measures to take to further decrease your flood risk level:

### Potential to decrease Risk Level:

- Become a member of Mass WARN
- Install Protective Structures

### **For More Information:**

Alan Slater  
[Alan.Slater@state.ma.us](mailto:Alan.Slater@state.ma.us)  
617-292-5749

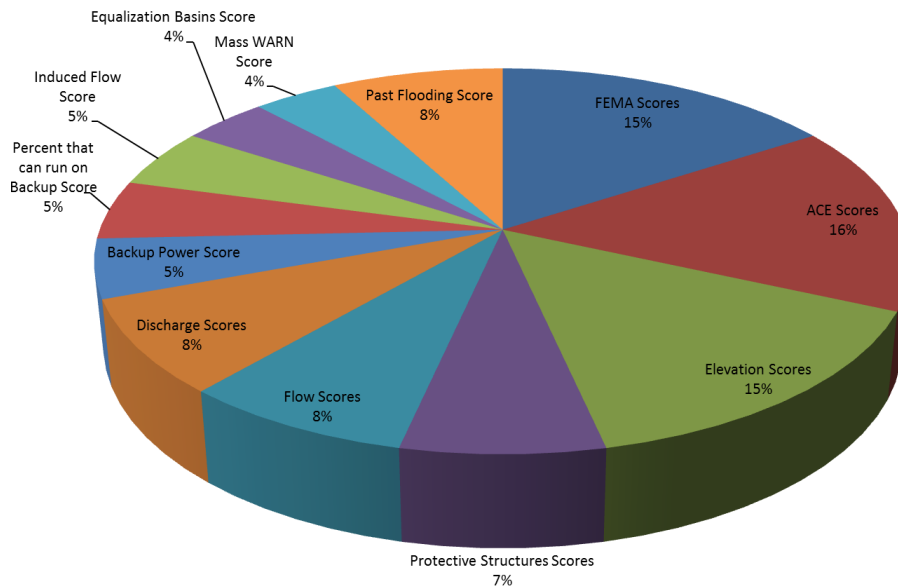


# APPENDIX E: RISK ASSESSMENT TOOL SUMMARY SHEET

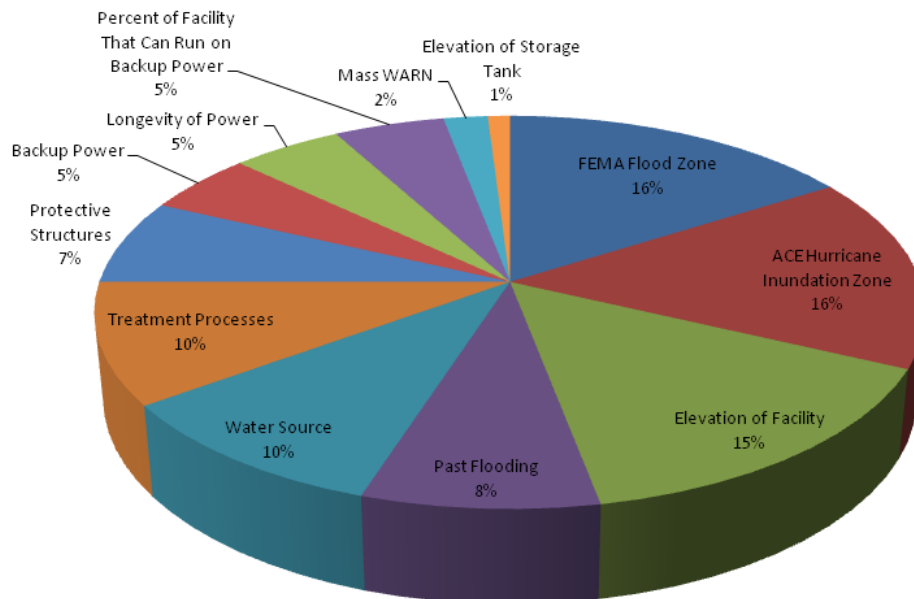
## Abstract

A team from Worcester Polytechnic Institute (WPI) has been working in collaboration with Mass DEP to develop a climate adaptation tool that would assess and quantify the risk of drinking water and wastewater treatment facilities along coastal Massachusetts due to sea-level rise. After the tool was developed, it was applied to a random sample of 23 different coastal treatment facilities to identify the risk at those facilities. Once this was completed, the overall data from the tool was collected and packaged to present to these facilities as well as various stakeholders of the facilities.

### Wastewater Risk Factor Weights



### Drinking Water Risk Factor Weights



## The Risk Assessment Tool

The tool is not a tangible object, but a calculation system that can be used to quantify a facility's risk of flooding. It was developed by creating a list of important factors that were narrowed down according to their relevance and importance to a water treatment facility. Once these factors were settled on by both the WPI team and Mass DEP as a relevant set, the process of addressing weights to each factor and developing a scoring method for each began. The decision was made to make the tool on a scale of 0-100. 100 is the maximum score a facility can receive and the highest possible risk level. The individual factors' weights/percentages add up to 100 at the maximum for each. The factors and their individual methodologies are as explained in the following pages. Factors that are specific to either wastewater or drinking water facilities are indicated by WW or DW next to the factor title.

### ***FEMA Flood Zones***

A facility's presence in a FEMA (Federal Emergency Management Agency) Flood Zone had an overall weight of sixteen percent in the tool, giving them a maximum score of sixteen for this factor. FEMA Flood Zones show the area that will flood during a 100-year or 500-year storm. There are three possible outcomes; a facility can be in a 100-year flood zone, 500-year flood zone, or be in neither flood zone. If a facility is in neither flood zone it receives a score of zero as this is the best possible outcome. If a facility is in a 100-year flood zone it receives a score of sixteen as statistically this is more likely to occur than a 500-year flood. A score of eight is given to a facility that falls within a 500-year flood zone as it is not as detrimental as being in a 100-year flood zone but not as good as being in neither.

### ***ACE Hurricane Inundation Zone***

A facility's presence in an ACE (Army Corp of Engineers) Hurricane Inundation Zone was also weighted at sixteen percent of the overall tool and a facility is given a score based on which zone they fall into, if any. ACE Hurricane Inundation Zones show the areas that will flood during different categories of hurricanes. Since the model is elevation-based, the lower category hurricane inundation areas are given a higher score because they have a higher probability of flooding and will also flood at higher category hurricanes. There are five possible outcomes for this factor; a facility can either be in no hurricane inundation zone or be in the inundation zone for a category one, two, three, or four hurricane. If a facility is not in any inundation zone it is assigned the best possible score of zero. A facility in a category four will receive a score of four, a category three is assigned a score of eight, category two is assigned twelve, and a category one is assigned a score of sixteen.

### ***Elevation of the Facility***

The elevation of a facility is the third highest weighted factor in the tool with a weighting of fifteen percent. The elevation of each facility was determined using GIS software. A box will be placed around the facility and elevation will be taken at the four corners and at the center. An average elevation will be taken using these five elevations. The facilities receive their score for elevation based on a sliding scale ranging from zero to fifteen. If the elevation of a facility was at or below mean sea level (MSL), then the facility received a score of fifteen. However, if the elevation of a facility was above MSL and below ten meters above MSL a score of twelve was assigned. Between eleven and twenty meters above MSL received a score of nine, between twenty-one and thirty meters above MSL received a score of six, between thirty-one and forty meters above MSL received a score of three, and any facility above forty meters above MSL received a score of zero.

### ***Water Source***

The source of water was very important when considering whether or not a facility was at risk from sea-level rise. If the salinity level in the water were to increase it could contaminate the drinking water and make it undrinkable. There are three types of drinking water sources: surface water (SW), ground water under direct influence from surface water (GWUDI), and ground water (GW). This factor had a weighting of ten percent in the tool. If a drinking water facility received its water from either surface water or ground water under direct influence from surface water a score of ten was recorded. If a facility received its water from a ground water source that was not under direct influence a score of zero was recorded. Many facilities received their water from more than one source. For this reason only the highest score would be recorded. For example, if a facility had two ground water sources and one surface water source, only the score for their surface water source was recorded.

### ***Treatment Processes***

There are many treatment processes that a facility can perform on drinking water. If contaminated or shut down they each would have a different level of difficulty in replacing and restarting these treatment processes. The treatment processes a facility uses had a weight of ten percent and considered four different treatment processes: chemical addition, conventional filtration, direct filtration, and membrane filtration. Chemical addition was assigned a score of two, conventional filtration a score of eight, and direct filtration and membrane filtration received a score of ten. Some facilities use multiple treatment methods in their facilities and as a result only the highest score was recorded.

### ***Past Flooding***

If a facility had a history of past flooding, there was reason to believe that this could have been considered a good predictor of future vulnerability to flooding. For this reason past flooding was weighted as eight percent of the overall score. If a facility has had past flooding they were assigned the maximum score of eight, otherwise they were assigned a score of zero.

#### ***Precautionary or Protective Measures***

The reason that history of past flooding was not weighted higher was because we did not want to falsely place a facility at a higher risk level that have had past flooding, but have taken measures to mitigate future flooding. We have accounted for this by including a factor for whether or not a facility has installed any protective or precautionary structures that will protect their facility in the event of a storm or flood. If a facility has precautionary protective structures they are assigned a weight of zero or seven if they do not have any protective structures.

#### ***Average vs. Design Flow Rate (WW)***

It is important that a facility's average flow rate is below their design flow. The difference between a facility's design flow and actual flow is the amount of extra flow a facility can handle in the event of a storm. This factor was given a weight of eight percent in the tool and was calculated using a ratio. The ratio was calculated as actual flow divided by design flow and multiplied by the total weight of 8. For instance, if a facility's actual flow was half of their design flow they received a score of four and if their actual flow was equal to their design flow they received a score of eight.

#### ***Discharge Source (WW)***

Whether a facility had a ground or surface discharge was given a weighting of seven percent. A facility could either discharge their treated water into the ground or onto the surface, such as into a marsh. A facility that discharges into the ground is more at risk because the pipe is more likely to back up than a pipe discharging onto the surface. Therefore a ground water discharge is assigned a weight of seven while a surface water discharge is assigned a score of zero.

#### ***Onsite Power (DW)***

In the event that a storm causes a facility to lose power they will need to generate power in order to keep up with the flow into the facility. It is important that a facility can produce its own power until power is restored. If a drinking water facility had onsite backup power generation, the facility was given a score of zero. If the facility did not have onsite backup power or had portable power which was not easily accessible, the facility was given the maximum score of five.

#### ***Longevity of Backup Power***

Longevity of a facility's backup power was weighted at five percent. This factor can be scored on a sliding scale from zero to five. If a facility had no backup power and could not operate after losing power they were assigned the maximum score of five. A facility that could produce enough power for up to three days was assigned a score of 4, between three and six days was assigned a score of three, between six and nine days was assigned a score of two, between nine and twelve days was assigned a score of one, and any facility that could produce enough power for twelve or more days was assigned a weight of zero.

#### ***Percent Processes that can run***

It was also important for us to take into consideration how much of the facility that could be powered from the backup power. This factor accounts for five percent of the overall tool and was calculated as the percentage of the facility that is operational under backup power multiplied by the weighting of five. If a facility did not have backup power it was automatically assigned a score of five, the maximum score.

#### ***Rainfall Induced Flow (WW)***

Some facilities can be subject to rainfall induced flow during heavy rainfall. If the amount of rainfall induced flow causes a facility to exceed its design flow, then there would be a higher risk of flooding at the facility. This factor made up five percent of the overall weighting in the tool. If a facility was not subject to rainfall induced flow or if their rainfall induced flow did not cause them to exceed their design flow they were assigned a score of zero. If the rainfall induced flow caused them to exceed design flow by up to ten percent they were assigned a score of two, between ten and fifty percent over design flow were assigned a score of three, between fifty and one hundred percent were assigned a score of four, and any facility whose rainfall induced flow caused them to exceed design capacity by over one hundred percent was assigned the maximum score of five.

#### ***Equalization Basins (WW)***

Equalization basins allow facility's to handle large amounts of induced flow by storing the raw water before entering the facility. This could help to prevent the facility itself from flooding. Whether or not a facility had equalization basins was assigned a weight of four percent in the tool. If a facility had equalization basins they received a score of zero, if a facility however did not have equalization basins they were given the maximum score of four.

**Member of Mass WARN**

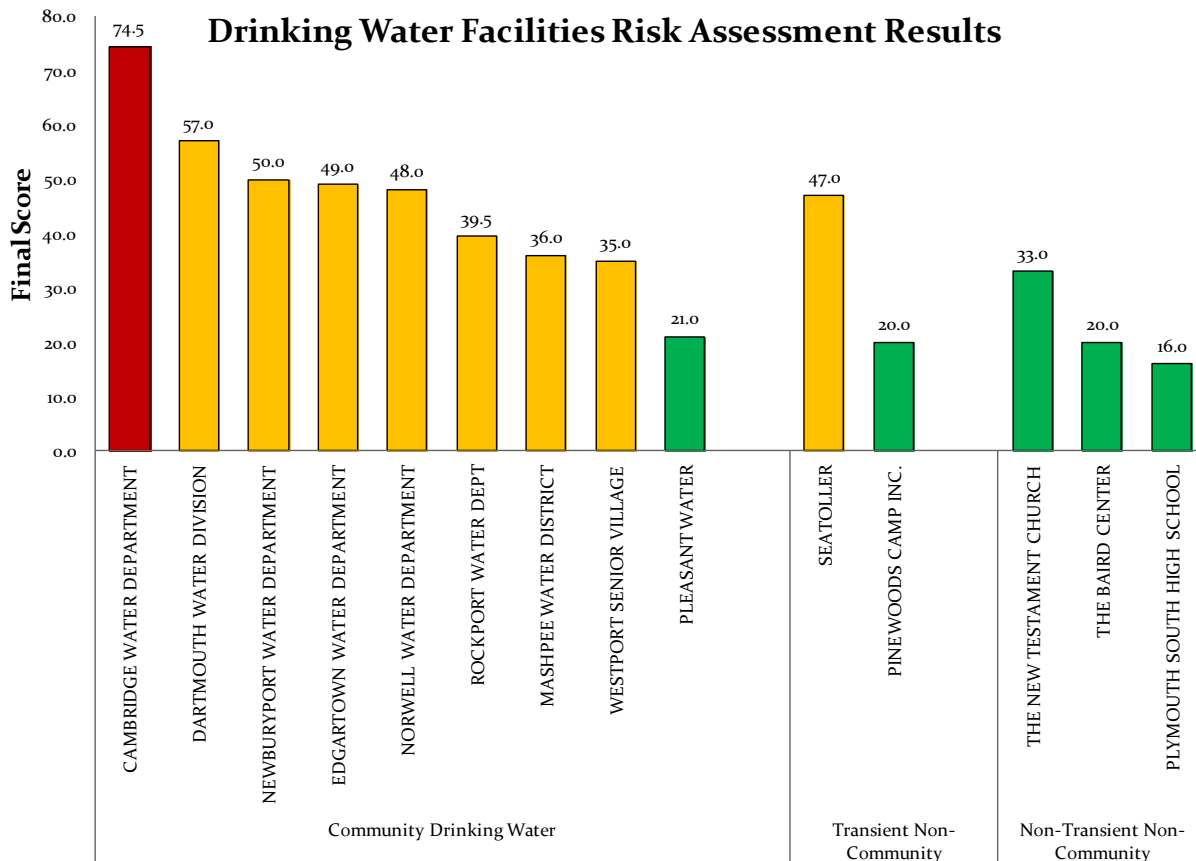
The last factor for drinking water or wastewater treatment facilities was whether or not the facility was a member of Mass WARN (Water and Wastewater Agency Response Network). Being a member of Mass WARN gives a facility access to critical equipment and parts during a time of need. If a pump breaks down at a facility they would be able to bring in a replacement temporary pump until a permanent one is able to be installed. This risk factor was weighted as four percent for wastewater facilities and two percent for drinking water facilities. If a facility was a member of Mass WARN they received a score of zero, if however they were not a member they received a score of four.

**Elevation of Finished Storage Tanks**

Finished water storage tanks are usually covered and not subject to inundation unless there is a fault in the tank. However, a finished water storage tanks should not be under water for any reason. The elevation of the finished water storage tanks were weighted at one percent of the overall tool as a less than significant factor, but considered nonetheless. If the bottom of the finished water tank was at or below ten meters above MSL a score of one was recorded. For an elevation higher than ten meters above MSL a score of zero was recorded.

**Summary**

This tool will allow coastal wastewater treatment facilities in Massachusetts to quantify the risk they face due to sea-level rise. It may serve as a reference for facility managers to show agency officials and a variety of stakeholders the relative risk level at given facilities. This may provide governing bodies with reason to take action or provide funding for facilities that are faced with the adverse effects of the rising sea-level.



## Wastewater Facilities Risk Assessment Results

