Supporting Implementation of a New State Law Requiring Public Notification of Combined Sewer System Overflows

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Abstract

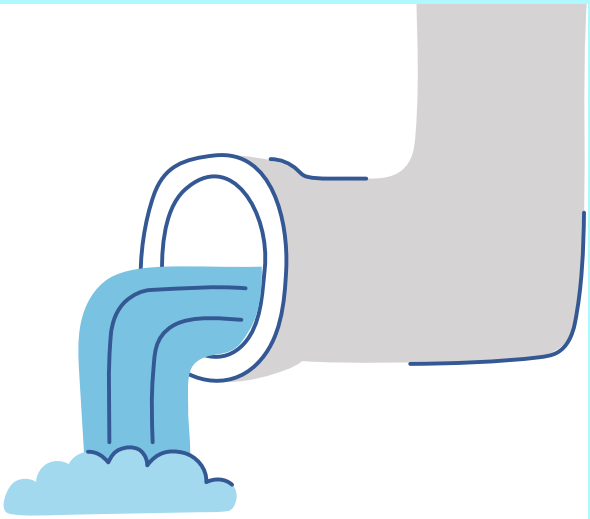
Massachusetts uses combined sewer systems, which experience overflows due to their structure. Combined sewer overflows (CSOs) are events that occur due to extreme precipitation, causing an overabundance of water. This water is then discharged into Massachusetts water bodies carrying with it sewage, wastewater, and street runoff. Our project goal is to help the Massachusetts Department of Environmental Protection implement Chapter 322 of Acts 2020, An Act Promoting Awareness of Sewage Pollution in Public Waters. This Act requires that a notification system is implemented to communicate CSO events to the affected residents and parties. Our research focused primarily on environmental justice communities, which are groups of Massachusetts residents that are most affected by CSOs and meet at least one of the specific criteria based on language proficiency, income, and minority status. Our purpose is to recommend the most effective communication platform for notifications, signage templates, and recommend additions for a GIS map of CSOs. To complete our objectives, we created a survey for environmental justice organizations, a questionnaire for the public, and conducted a semi-structured interview with the director of the Massachusetts River Alliance. The data we collected suggests that sewage discharge event signage must be redesigned and there is no one effective alert platform. Notifications should be issued in the most spoken languages in Massachusetts.




Introduction

Combined sewer overflows (CSOs) occur when wastewater is released into public waterways to prevent any excess wastewater from backing up into residential homes. Since CSOs may carry sewage into the waterways, they pollute the water bodies with chemicals and bacteria. Such pollutants are health hazards for people interacting with the water [20]. Massachusetts currently lacks a communication system that addresses CSO events. The Act Promoting Awareness of Sewage Pollution in Public Waters (Chapter 322 of Acts 2020) was passed to establish an alert system addressing the issue. Our plan was to investigate the most effective way to communicate CSOs to the public and recommend outreach methods that meet the requirements of the Act.

Massachusetts Department of Environmental Protection (MassDEP) is a government agency that addresses environmental hazards, one of which is combined sewer overflows. The MassDEP is responsible to oversee that Chapter 322 of Acts 2020 is implemented for all permit holders in the State. Currently, our sponsors at MassDEP want to understand the notification system preferences of the affected communities.



The MassDEP is most concerned about reaching under-represented communities like environmental justice (EJ) communities. EJ communities have historically lacked political representation. Environmental justice communities are categorized as such based on income, minority status, and English proficiency [2]. In Massachusetts, environmental justice communities live in areas susceptible to CSOs. We recommended a communication system that caters to the needs of these affected communities. We investigated the perspective EJ communities have on CSOs in our research.

The goal of the project was to recommend an outreach and notification plan which will notify the public of sewage outfall events. To do so, we identified the perspective of communities affected by CSOs, recommended a GIS Story map that communicated the background and information of CSOs, and investigated and recommended different outreach methods which meet the Act's requirements.

PROBLEMS OF COMBINED SEWAGE SYSTEMS

Massachusetts utilizes an old combined sewer system (CSS) for handling waste. Combined sewer systems are older forms of water infrastructure in which untreated or partially treated sewage is released into water bodies alongside runoff during heavy precipitation events. CSS have weir walls that keep the wastewater from backing up through the pipes into people's homes. The weir walls allow the wastewater to overflow into the public waterways to avoid costly damages to the residential areas [17].

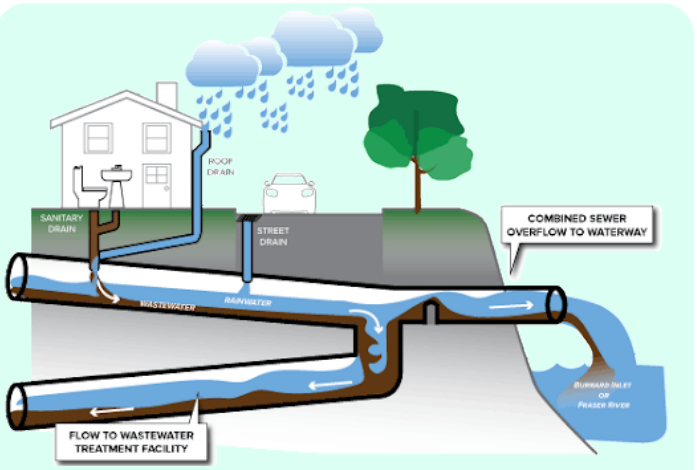


Figure 1: Diagram of Combined Sewer System [7]

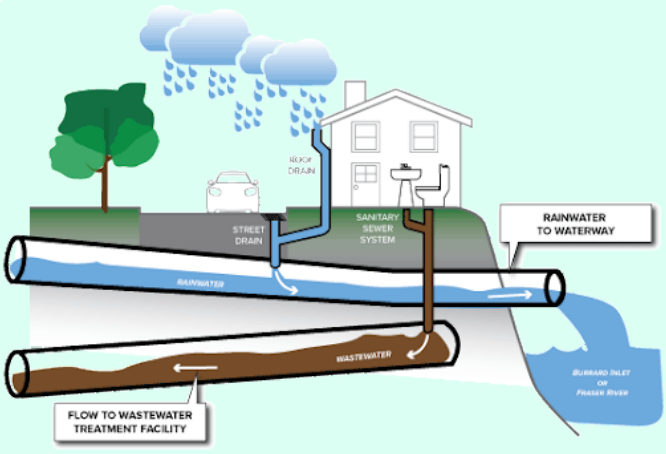


Figure 2: Diagram of Separate Sewer System [7]

Separated systems use separate pipes for sewage and precipitation drainage (as shown in figure 2). More modern sewage systems have moved away from combining rain wastewater and sewage in the same pipelines by utilizing separate sewage systems. Currently, replacing combined sewage systems with a separate system is costly, as in Stony Brook Massachusetts where the sewer separation cost over 44 million dollars. However, the frequency for discharges went from 22 to only 2 a year after the replacement [31].

Water treatment helps limit the effects of CSOs by eliminating harmful particles from the sewage before releasing wastewater into the waterways. Wastewater treatment follows two steps before the water is released. Initially, any large solids that sink or float are removed. Then, materials are broken down and treated with chlorine to remove micropollutants [47]. Some treatment plants are too small to treat all the contaminated water during extreme precipitation. Instead of treating all the water, a method known as "blending" is used, which combines treated and untreated water to maximize efficiency [47]. Blending has raised criticism since it does not completely treat water that has been contaminated with raw sewage. Sewer overflow events increase pollution in Massachusetts waterbodies and infect clean water with microorganisms, such as bacteria, protozoa, and viruses [20]. Some examples of other pollutants are estrogens, caffeine, and propranolol [37].

HEALTH HAZARDS OF OVERFLOWS

As well as polluting Massachusetts water bodies, CSO discharges can cause health issues. Fish and shellfish can spread water contaminants following CSO discharges. The consumption of fish or shellfish can cause people to become infected with sewage-related illnesses. [36] A study was completed in Massachusetts and focused on CSO events and emergency room visits. Patient data was collected for ER visits that were related to gastrointestinal (GI) problems. Three different regions of Massachusetts were used to compare different types of exposure to contaminated water; through drinking water sources exposed to CSO's, through swimming or boating (recreational use), and no exposure. Following higher than normal precipitation, GI-related ER visits increased by 13% for those exposed to drinking water coming from reservoirs exposed to CSO's, with this increase lasting for 8 days [20].

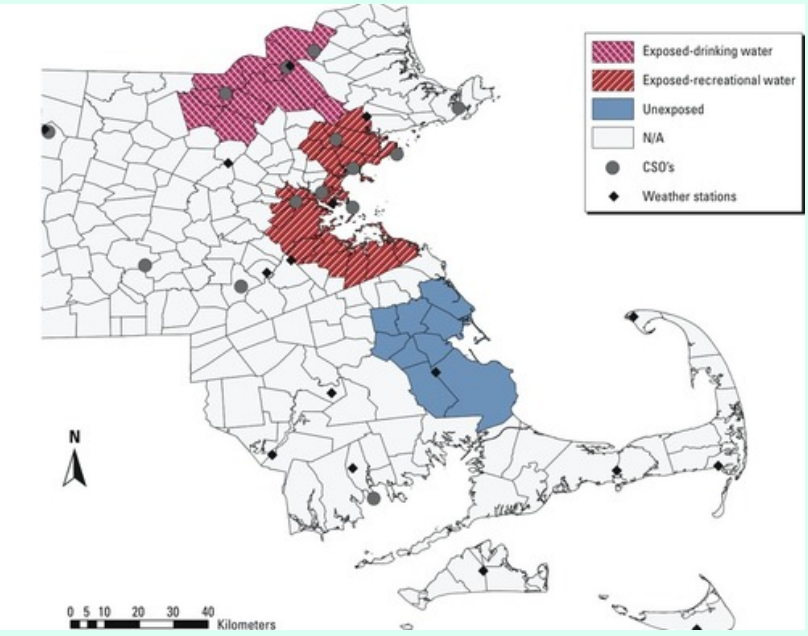


Figure 3: Regions affected by CSOs based on exposure types [20]

ENVIRONMENTAL JUSTICE COMMUNITIES

The communities most affected by sewage overflows are environmental justice (EJ) communities. EJ communities are legally defined as communities where,

> "(i) the annual median household income is not more than 65 percent of the statewide annual median household income [or $52, 790 as of 2019]; (ii) minorities comprise 40 percent or more of the population; (iii) 25 percent or more of households lack English language proficiency; or (iv) minorities comprise 25 percent or more of the population and the annual median household income of the municipality in which the neighborhood is located does not exceed 150 percent of the statewide annual median household income" [2].

A community qualified as an EJ community meets one or more of the above requirements [2]. EJ communities have historically faced a lack of government representation. In Massachusetts, Chapter 322 of Acts 2020 was established to notify the community members regarding sewage overflows and communicate any associated health hazards.

COMMUNITY RIGHTS TO KNOW ABOUT COMBINED SEWER OVERFLOWS

Currently, the aging water treatment plants are unable to accommodate the growing population of Massachusetts while handling any severe weather conditions. The environmental and public health threats caused by untreated sewage have been topics of discussion in the Massachusetts Government. Governor Baker "has filed a $2.9 billion plan (H 3922) that includes $400 million for water and sewer infrastructure upgrades and another $300 million to improve culverts, dams and other infrastructure." [38] Until the potential upgrades are made, untreated wastewater has been entering the waters without public notice, disregarding the people's safety. Kathleen Theoharides, an energy and environmental affairs secretary, strategically testified the need for the upgrades on September 9th, 2021 from the banks of the Merrimack River in Lawrence, Massachusetts, where over only two weeks, 130 million gallons of untreated wastewater was released into the river as a result of Tropical Storm Ida. "The time to invest in adaptation is now. It's not tomorrow or the next day," said Kathleen Theoharides, but since we do not know when the upgrades will be made to the treatment plants, the public has the right to know when untreated wastewater enters public waterways [38].

ACT PROMOTING AWARENESS OF SEWAGE POLLUTION IN PUBLIC WATERS (CHAPTER 322 OF ACTS 2020)

Chapter 322 of Acts 2020, also known as the Act Promoting Awareness of Sewage Pollution in Public Waters, describes communication requirements for the treatment plant facilities and organizations which hold permits to oversee outfall events (permittees) regarding sewage discharge. It also sets requirements for the Massachusetts Department of Environmental Protection (MassDEP) regarding communicating with the permittees.

The permittees are required to issue a notification through email or text messaging in an event where more than one outfall is discharged into a single waterway. The advisory must be issued two hours after the discovery of discharge. They must update the advisory every eight hours for ongoing discharges, as well as within two hours after the discharge stops. The notification must disclose the location of the outfall, discharge time, date, duration, and estimated volume based on average discharge indicated in the three prior years.

The permittees should also indicate the water and land affected, permittee identity, measures to avoid health hazards, and whether the sewage is treated, partially treated, or untreated. Two major local news stations should be contacted during an outfall event. The department of public health in the outfall region should receive an advisory. The permittees must also create a public website for advisories and notifications. The MassDEP commissioner has the power to extend the deadline for sending notifications, but only in appropriate scenarios and in no longer than 24 hours.

MassDEP should provide information about discharges on their website, issuing a report summarizing all outfalls in the previous year (deadline is May 15 each year). The report should include total discharge volumes, frequencies, and pretreatment at any outfall location.

MassDEP requires permittees to place signage at the outfall locations and near the public waterways which could be affected by the discharge. The signs should be placed near boat ramp entrances, piers, and swimming areas. MassDEP will assign the size and shape of the sign. The signs must also comply with further regulations. The permittee and agency will coordinate with the department of conservation and recreation local to the location of the outfall, local governments, and facilities in charge of public water access points to place and maintain CSO signage.
Each sign must contain the following information:

1. Notice of sewage and wastewater outfall
2. List weather events that may cause discharge
3. Warning regarding health hazards that may result from contact with sewage-contaminated waters and shores
4. Information about subscribing to notifications about CSO events in local outfalls
5. Other information enforced by MassDEP

Additionally, MassDEP has expressed the need for standardization of signage across Massachusetts and the inclusion of infographics to communicate the issue despite the potential language barrier. [3]

Figures 4: Current outfall sign in Lynn, MA

ENVIRONMENTAL HAZARD COMMUNICATION

Environmental hazard communication is an integral part of keeping the public safe and informed, making it crucial to establish an effective plan to inform the largest number of people in affected communities. Alert messages should be catered to the perspectives and character of the communities affected to educate and inspire action. [44]. To build an outreach program that fits the needs of the community, one must first learn about the community's culture. Thus, the messages and warnings most fit for the affected areas will be issued. [4]

The Department of Homeland Security conducted a study on alert technologies used to communicate environmental hazards at the Mississippi Gulf Coast. The study investigated TV, radio, NWR (news radio), sirens, reverse 911 calls, WEA messages (phone alerts), internet (agency website), social media, posters, and door-to-door visits.

For our research, we will focus on WEA messages, social media, the internet, reverse 911 calls, posters, and door-to-door visits. The overall effectiveness of each method is determined by the awareness of issues, awareness and use of alert systems, and motivation for the public to take action either through safety precautions or by helping repair the damages caused by the hazards. In terms of overall effectiveness, WEA message and door-to-door visits have ranked highest in the "most effective" option on the survey. Reverse 911 calls and WEA messages ranked highest in the "often effective" option, with the internet and social media following. Agencies have indicated that they would prefer to issue alerts through social media. [48]

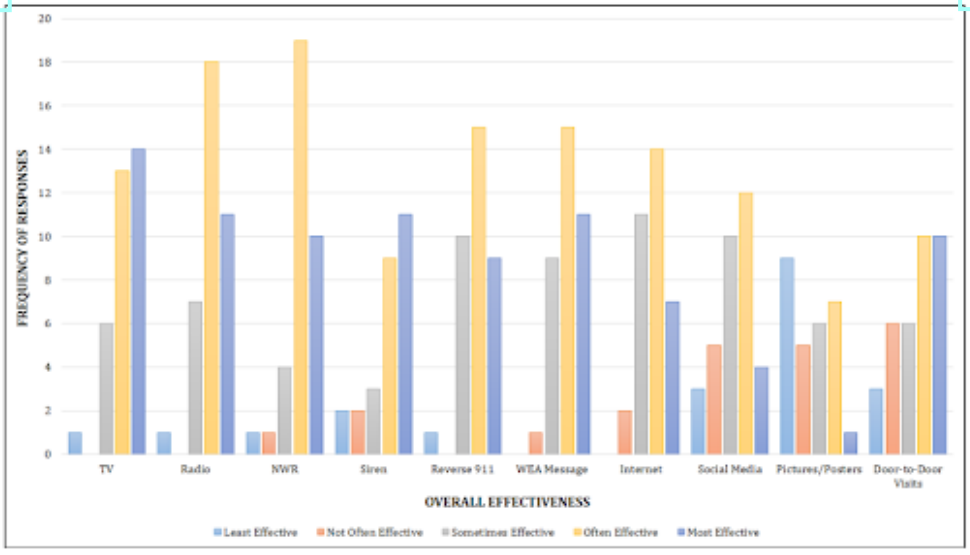
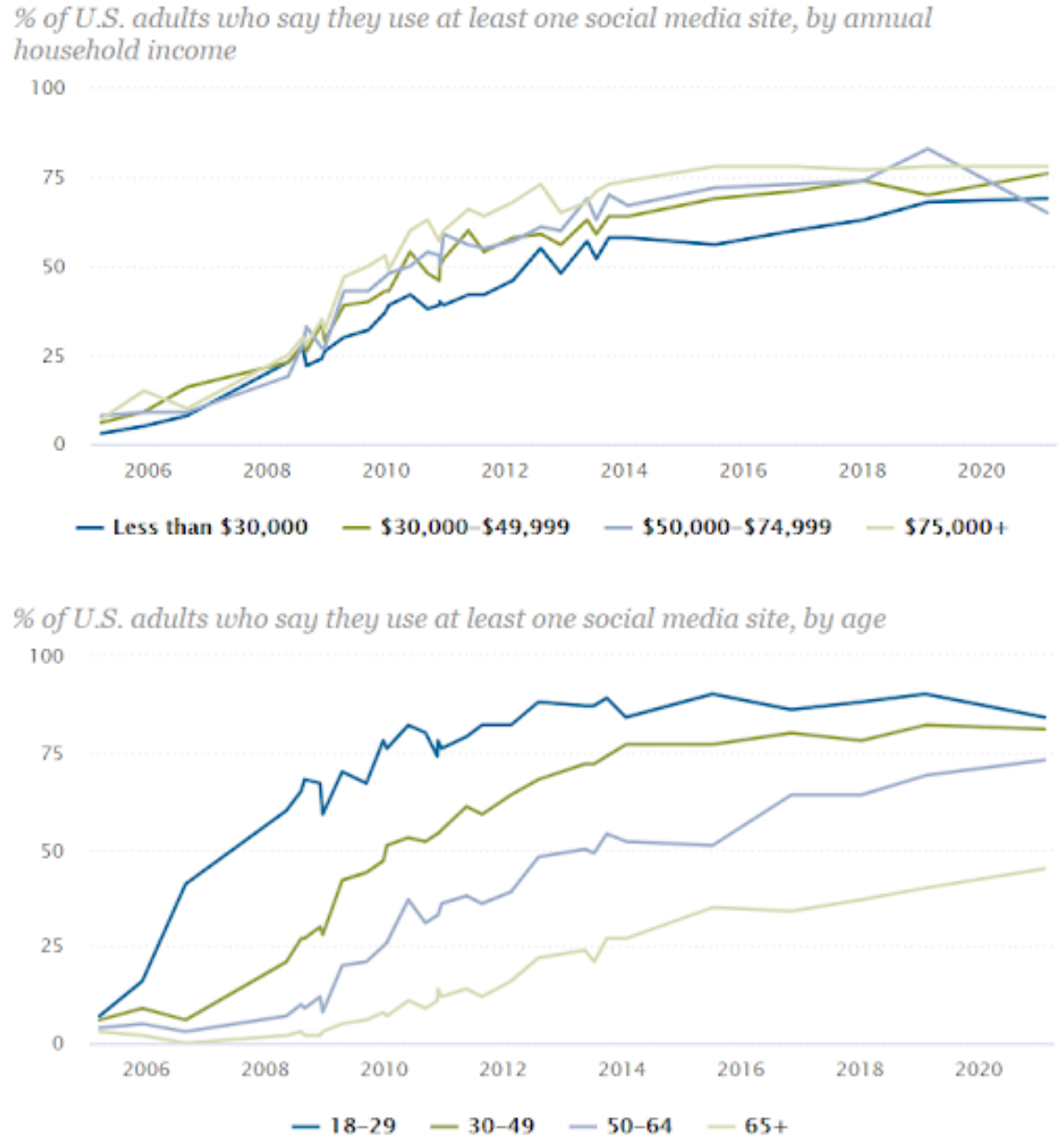


Figure 12: Overall Effectiveness of Each Device/Channel Used by County EMA

Figure 5 [48]

Our sponsors at the MassDEP indicated that they would like us to research social media communication for environmental hazards. Recently, social media has been utilized by government organizations to relay important information to the public. Currently, 45% of those over the age of 65 use at least one social media platform, while 84% of those between the ages 18 and 29 report using social media. In Massachusetts, many CSO locations are in urban areas where the majority of environmental justice communities are located. Social media use is widespread across age groups and in communities with different economic profiles. [43]



Figures 6 and 7: Graphs of distributions of people using social media based on income and age. [43]

CSO COMMUNICATION IN OTHER STATES

To develop a widespread communication system for combined sewer overflow events in Massachusetts, we learned from communication systems created in other states. Connecticut, Vermont, and New York have well-developed outreach plans to communicate CSO events.

CONNECTICUT

Connecticut utilizes website postings to communicate CSO events. Due to the Act passed in 2012, An Act Concerning the Public's Right to Know of a Sewage Spill, Connecticut cities and districts are required to report CSO events as well as any relevant data.

Two maps can be found on the Connecticut Department of Energy and Environmental Protection website. The first map allows the user to click on a municipality, and use arrows to scroll between each of the CSO locations in that municipality. The second map is a GIS map with real-time information, and allows the user to click on the CSO event location. [12]

VERMONT

In Vermont, the issue of Combined Sewer Overflows is overseen by the Department of Environmental Conservation. In 2016 Vermont adopted a rule, the Environmental Protection Rule Chapter 34: Combined Sewer Overflow Rule, as a regulation of Act 86, an act which protects the rights of Vermont citizens to know about water contamination to reduce the effects of combined sewer overflows on the waterways [16]. The rule directs Vermont cities and districts on establishing a CSO monitoring system [13]. The agency also requires the treatment facility members to issue communications in case of CSO discharge events. The rule states that treatment plant operators must issue a public electronic media notification no longer than one hour after the discovery of CSO discharges.

The agency, cities, and facilities responsible for issuing alerts use emails and text messages for notifications which the residents can subscribe to on the Department of Environmental Conservation website. Subscribers have the choice of receiving notifications for the entire state or outfall locations closest to their residency. [17] The agency also posts any outfall events on their website, listing the facility in charge of the outfall, the city the outfall is located in, the description of the location, the waters that have been affected, and the date and ID of the entry submission [45]. Hence, the residents of Vermont have multiple ways in which they can receive the CSO event information from the agency.

Figure 8: Vermont permanent CSO sign [16]

The Department of Environmental Conservation provides cities and facilities with two signs for CSO outfall locations. One of the signs is temporary and must be put downstream of the outfall location in case of a CSO event. It must remain there for 48 hours after CSO discovery. The template for this sign is available on the Vermont State Website. The other sign must be permanently placed next to outfall locations. The sign explains the issue of discharge events and the next steps which should be taken in case of such events. It also contains infographics communicating that people should not be swimming, fishing, or boating next to the outfall. [16]

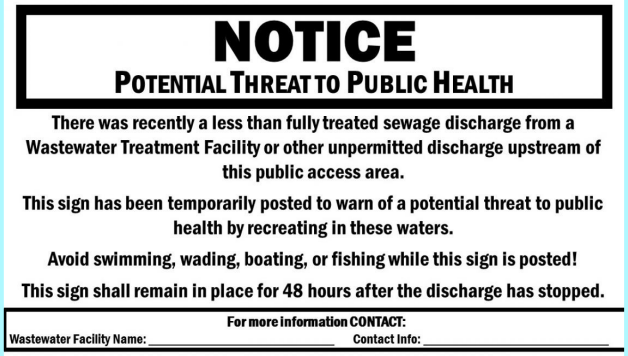


Figure 9: Vermont temporary CSO sign [16]

NEW YORK

New York City passed the “Sewage Right to Know Law” in 2012 to help prevent the public from being exposed to any raw sewage pollution in the city's waterways. The New York Act was aimed to accomplish this goal by requiring publicly owned treatment works (POTWs) and publicly owned sewer systems (POSSs) to report the overflow events. These publicly owned facilities are required to notify the Department of Environmental Conservation (DEC) within 2 hours, and the public and adjoining municipalities within 4 hours of the discovery of a discharge event. At the end of the year, the DEC sends out a “statewide sewage discharge report” that goes over all discharge events that year and any actions taken in response to some of the overflows [41].

New York City communicates the overflows with the public in a handful of different ways. Firstly, NYC offers a notification system with a lot of customizability. The NY-Alert is a “mass notification system used to warn citizens of emergencies and critical information in a timely manner to help protect lives and keep New Yorkers safe.”[35] New York tries to compensate as many residents as they can by providing multiple platforms to receive the notifications that you specify while registering for the NY-Alert. NY-Alert allows users to receive warning messages and emergency information directly to their phone or email. Another notification customization NYC offers is the ability for residents to select the counties they want to receive alerts from.

An important aspect to mention about the NYC notification system is their website to always give the public information on CSO discharges. NYC posts the CSO historical sewage data as well as all the recent data, which is all available via a spreadsheet. On the DEC.NY.gov website, recent NY-alerts are displayed and contain the important information of a discharge, including the date/time of discharge, location of discharge, duration of discharge, volume of discharge, treated state of discharge, reason(s) for discharge, and a description of corrective action(s). This allows for the public to have access to all the information needed. [40]

SUMMARY

The discharges from Combined Sewer Overflows result in polluted waterways that cause negative impacts on the health of Massachusetts communities. Environmental justice populations are affected the most by these discharges. Acts mandated by MassDEP address communication systems for alerting these communities about the hazards.

GOAL

The goal for this project is to recommend a fast, informative, standardized, and universal outreach system regarding Combined Sewer Overflow (CSO) events to inform the affected Massachusetts residents. Our research serves to answer the following questions: What are the opportunities for implementing Chapter 322 of Acts 2020? How do we create interventions to increase awareness of CSO events in compliance with the Act? What are the most effective ways to message and reach environmental justice populations, organizations, and the public about CSO events? To achieve our goal and answer the above questions, we have created three objectives:

1. Identify the separate parties involved in the CSO issue and identify their and the public's desired communication methods for CSOs.
2. Research additions to the existing Massachusetts CSO locations GIS map
3. Investigate and recommend different outreach methods, designed to engage the Massachusetts communities affected by CSO events.

Figure 10: CSO outfall in Lynn, MA

IDENTIFYING THE SEPARATE PARTIES INVOLVED IN THE CSO ISSUE.

We have created a stakeholder map to help break down the relationship between the different parties involved in the CSO issue. Stakeholder mapping helps evaluate the complex system of relationships between the involved parties [5]. The circles on the above map build a hierarchy of involved parties based on how closely the stakeholders worked with our group. Key stakeholders at MassDEP worked intimately with our group and were very influential with the direction of our project. Through our key stakeholders, we worked with our secondary stakeholders which are the environmental justice and watershed organizations. Tertiary stakeholders were parties that are affected by or involved in the issue, but didn't work closely with our group.

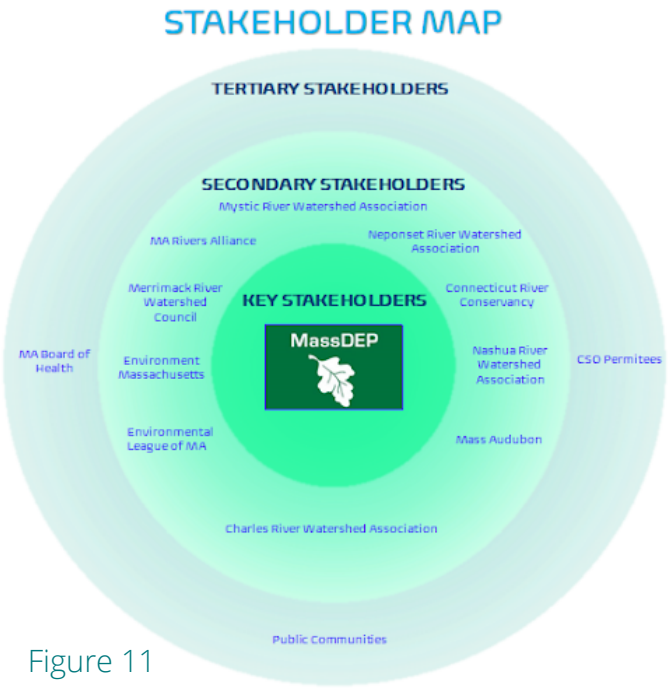


Figure 11

From the list of organizations provided by the DEP, we distributed a survey to the environmental justice organizations and a questionnaire for environmental justice communities and other members of the public including watershed organizations who advocated for Chapter 322 of Acts 2020. The public questionnaire focused on the community's knowledge of CSO events and their notification platform preferences. We inquired about potential logistical problems, such as internet availability. Our sponsors helped us contact EJ organizations with a survey and asked them to distribute the survey to the communities they represent.

The DEP made the public questionnaire available on their Twitter and Instagram to reach the public on a greater scale. The questionnaire and survey helped us obtain information quickly, and not take away significant amounts of time from the respondents. If the respondent indicated that they would be willing to discuss further questions, we conducted a short follow-up interview. After all data was collected, we analyzed it to make recommendations to the DEP for the preferred communication systems. For clarification, we refer to the "survey" as the data collection method for suggestions and preferences of the EJ organizations, while the "questionnaire" is the data collection method for suggestions and preferences of the public. The naming conventions are differentiated to avoid confusion by distinguishing between the deliverables. These deliverables differ in some content, but not on a technical level.

We also conducted a semi-structured interview with a department head of the Massachusetts River Alliance organization. Semi-structured interviews are useful tools to collect qualitative data, get answers to core questions, and allow for additional discussion. Massachusetts River Alliance is one of the several organizations that advocated for Chapter 322 of Acts 2020. This organization also served as the spokesperson for other organizations that advocated for the Act. The goal of the interview was to provide insight on the perspective of organizations that advocated for the Act regarding developing the communication system for CSOs. The interviewee also distributed our questionnaire to the member organizations of the Massachusetts River Alliance.

RESEARCHING ADDITIONS TO THE EXISTING MASSACHUSETTS CSO LOCATIONS GIS MAP.

A GIS map is an interactive map that relates geographical locations with geospatial data. The additional layers to the GIS map graphically overlay CSO locations with a variety of spatial data collected through research, allowing the user to customize the information they want to be displayed on the map [19]. We also made recommendations for layers of a GIS story map. A GIS story map is an interactive, multimedia, and narrative-based resource which provides the background of the data displayed on the map. The GIS story map will help the individuals affected by CSOs to get information on previous CSO events and what the dangers of sewage exposure are. The GIS CSO map is available to the public on the MassDEP website.

Based on existing GIS data, offered by the MassDEP as well as the Massachusetts GIS 'Oliver' (MassGIS), we collected and analyzed different geographical data point layers that would be useful when displaying the GIS map on the MassDEP's website. Some GIS layers that we needed may not have been collected yet or made available to the public. Some of the layers we included are environmental justice community locations, beach access, boat access, public surface water supplies, and shellfish growing areas. Other layers may be added depending on their relation to CSO locations. We obtained this data from the 'Oliver' GIS, Watershed Planning Program officials, and the GIS team at the MassDEP. We will also recommend pages to include in a potential future story map based on our research. The story map will give the user more background on CSOs, their effects on human health, and where to sign up for notifications in addition to the GIS map.

INVESTIGATING AND RECOMMENDING DIFFERENT OUTREACH METHODS, DESIGNED TO ENGAGE THE MASSACHUSETTS COMMUNITIES AFFECTED BY CSO EVENTS.

Figure 12: CSO sign in New York [15]

We researched potential communication methods and benchmarked signage templates with the established regulations and survey data. From these data sources, we chose the best methods for communicating CSOs.

By analyzing existing communication systems and signage in New York, Vermont, and Connecticut, we compared their implementation against specific Massachusetts legislation requirements. Benchmarking ensures that the signage meets the requirements of the CSO communication laws passed in Massachusetts as of 2020 [8]. We also benchmarked our recommended signage with the signs implemented in Vermont and New York.

We have developed signage templates. Our recommendations stem from CSO signage we have seen utilized in other states and signs currently established in Massachusetts as well as the requirements of the Act. The signage template serves to standardize CSO signage in Massachusetts.

Based on our results from our survey, questionnaire, interviews, and research of CSO communication in other states, we developed an outreach plan for the permittees and MassDEP. We ensured that our recommendations meet the requirements of the Act. We also ensured that the outreach plan caters to all affected communities.

DATA ANALYSIS

We delivered our survey and questionnaire through a survey program called Qualtrics. To cater to different public audiences, our questionnaire was made available in three different languages: English, Spanish, and Portuguese. We offered to deliver the questionnaire in other languages upon request. Once we reached the survey and questionnaire response deadline (September 27th for the survey, September 29th for the questionnaire), we started to organize the data we gathered.

Survey and questionnaire analysis began by first observing the general results. We identified any potential errors. According to an article on survey processing, survey response errors can be detected by the following data patterns: answers missing to certain questions, answers fall out of generally expected range (i.e. questionnaire respondent does not live in Massachusetts), non-logical answer pattern (i.e. respondent does not know what a CSO is, but knows what causes CSOs) [22]. We first identified any potential errors before we continued our analysis and made conclusions.

Most of our data was qualitative and was analyzed through a grounded theory lens. Grounded theory means that the data will guide our development of theories and findings through a rigorous coding and inquiry process [9]. Qualitative data analysis requires codes, which are terms or references that simplify provided data [10].

Survey analysis incorporates numeric codes by assigning values to answer options. For example, in surveys, the responses to a rating question (i.e. a question with options like “least preferred”, “moderately preferred”, “most preferred”) may be assigned numeric values in order to write the answers into a data table for further analysis [22].

To analyze our survey and questionnaire data we used Qualtrics, which gave us access to professional survey analysis tools and also streamlined the survey-taking experience. Qualtrics organized responses into tables. Such tables can be reorganized to perform separate field comparisons. Data tables can be graphed and results can be modified [14]. Qualtrics implicitly incorporates survey “coding” into its function.

We analyzed the data from the interview to compare suggested communication methods with the survey and questionnaire results. These results were compared against regulations and Chapter 322 of Acts 2020. To analyze interview results and answers to the free-response questions on the questionnaire, we manually coded the answers. We kept track of codes, terms or themes, during the interview itself as well as during analysis. [10] Since the survey response rate may not represent the majority of the audience members we were trying to reach, benchmarking our results with the established communications regulations and the Act was crucial. We then manually analyzed the relationships between different code sets and the regulations provided by the Act.

Results

In this section, we discuss the results of the data we collected through an EJ organization survey, public questionnaire, and interviews. All heavy qualitative data (survey and questionnaire open responses, the interview, and Chapter 322 of Acts 2020) was coded. The codes were categorized into general themes, and each theme was displayed in a pie chart. The qualitative data gathered through the survey and questionnaire questions are displayed in graph form.

SURVEY AND QUESTIONNAIRE

We received 135 responses on the public questionnaire that was sent through environmental justice organizations, an advocacy organization, and posted to the DEP's Twitter and Instagram. Because of the low social media post interactions, the DEP reported to us, we expected a 10% response rate from the questionnaire. The DEP currently has around 11,000 followers on its Twitter account. On Twitter, the public questionnaire post was retweeted 14 times and received 11 likes. The DEP Instagram account has 1,110 followers, and the public questionnaire post received 15 external likes. The questionnaire was also posted on the DEP's Instagram story and profile, each receiving around 90 views. The survey was emailed to 17 different EJ organizations, and we obtained 7 responses. Out of the 7 responses, 6 were from Lawrence, Massachusetts. Out of those 6 responses, 4 of them were from Groundwork Lawrence.

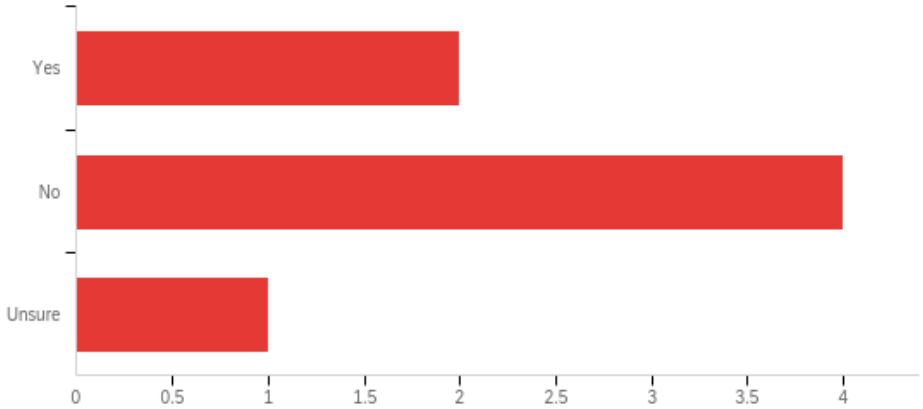
SURVEY

We want to address potential errors and response biases. Most (6 out of 7) of the responses come from members of organizations located in Lawrence, MA. Thus, the responses to questions may be biased towards environmental justice communities in Lawrence, and may not accurately reflect the responses of other Massachusetts communities. Secondly, while some members identified they were from Lawrence, they indicated that they are not affiliated with any organization. This is likely inaccurate considering this survey was sent out specifically to organization members. However, such respondents have also identified that they would like to remain anonymous, so that may be their reason for this response.

A majority of the respondents knew what a CSO was prior to taking the survey, as 4 indicated they knew what a CSO was, and 3 did not. Everyone who knew of CSOs was also aware of the associated health hazards. 3 respondents reported to have never heard a complaint about sewage discharges, while 1 hears a complaint every month, 2 weekly, and 1 every time it rains. 3 respondents were uncertain of the internet access availability in their communities. 1 indicated it is 20% to 30%, two indicated it is 60% to 70%, and one stated it is 80% to 90%. When it comes to using social media, 3 respondents state that 60% to 70% of their community use social media, two said 40% to 50%, and the rest were unsure (2 respondents). When asked to provide final comments, a suggestion was made that facilities should have a single place that archives all discharge events.

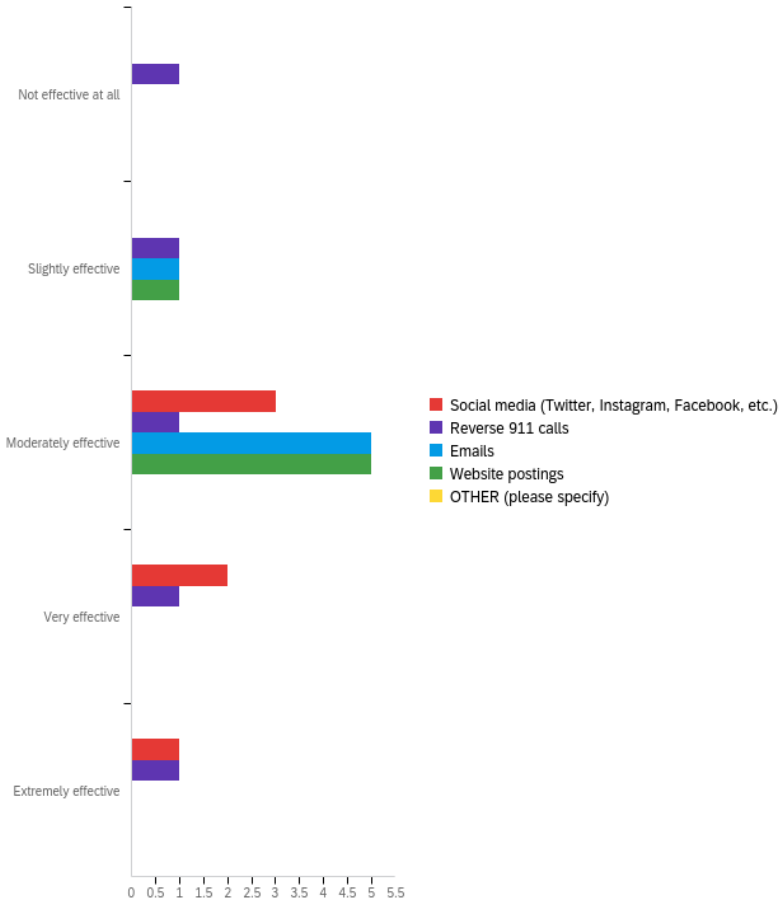
While 2 respondents did know of CSO signage in their communities, 4 did not, while one was unsure. A majority of the respondents were not aware of signage in their communities, which shows that signage maintenance could be a problem that should be addressed.

Do you know of any signage at sewage outfalls in your community like the one picture above?



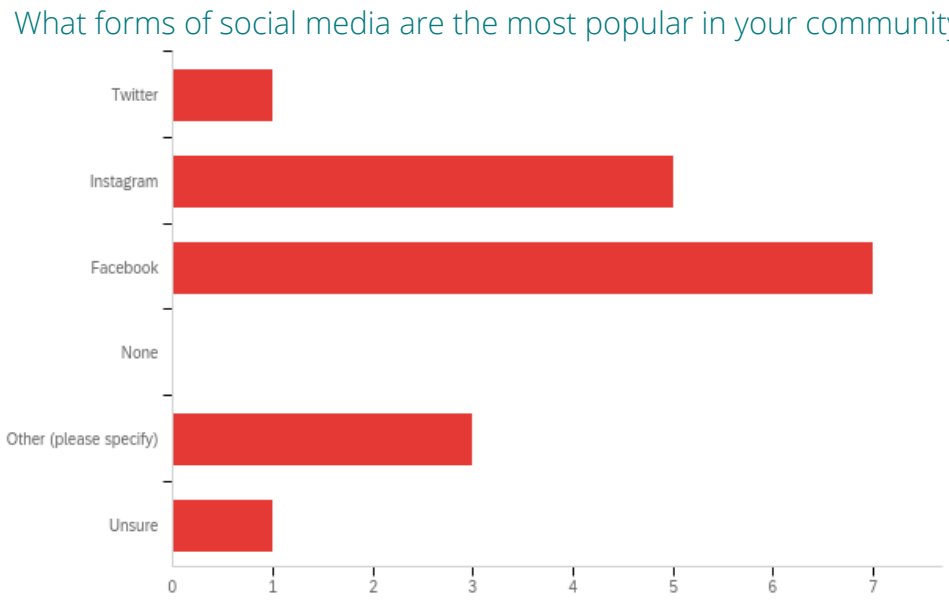
Graph 1: Survey responses to the signage question

Please rate the communication methods below on how effective they are in reaching the members in your community.



Graph 2: Survey responses to the media rating question

The communication platforms ranked most effective (based on the average) are social media and reverse 911 calls. Emails and website postings had the same average ratings. According to the graph, social media mostly received high ratings. Website postings and emails were rated as moderately effective and slightly effective, while reverse 911 had even distribution among ratings.



Graph 3: Survey responses to the social media question

From social media used, Facebook is the most popular (7 respondents), followed by Instagram (5 respondents). Some respondents noted that Whatsapp is another popular platform in their communities.

QUESTIONNAIRE

Now, we will summarize and analyze the results of the 135 responses from the public questionnaire. Our respondents consisted of EJ communities (reached through EJ organizations), members of the Massachusetts River Alliance (and their constituents), and the Twitter and Instagram followers of MassDEP.

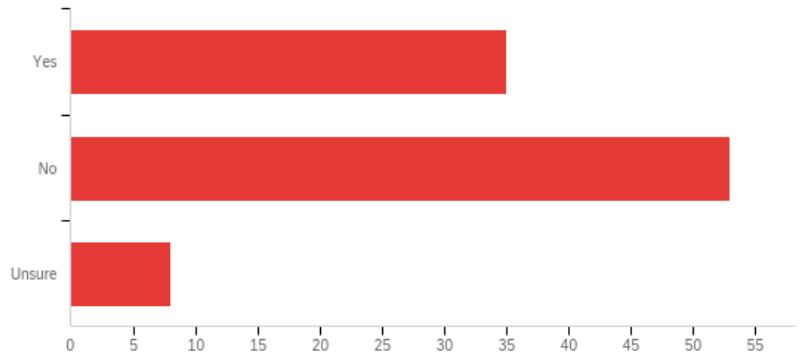
Since we have reached out to Massachusetts River Alliance organization members, organizations that advocated for Chapter 322 of Acts 2020, the majority of the respondents are affiliated with watershed organizations. In fact, only 34.75% of respondents (41 people) said they do not affiliate with any organization. This is important since organizations advocating for the Act have preexisting knowledge of the CSO issue, which a majority of the general public may be unaware of. Additionally, only one respondent affiliated with an environmental justice organization, Neighbor to Neighbor, meaning the majority of the responses to this questionnaire may not accurately represent knowledge and opinions of environmental justice communities. Not all 135 people have responded to every question.

The responses came from all over Massachusetts, unlike that of the survey. A few of the respondents indicated that they would like to receive notifications in languages such as Spanish, Vietnamese, Mandarin, Khmer (Cambodian), Arabic, and Portuguese. The roles of respondents in their organizations ranged from executive directors to volunteers and donors. Most of the respondents knew what a CSO was (87%). Even the respondents who do not affiliate with organizations were aware of CSOs (out of 36 who responded, 28 knew what a CSO was). The high rate of CSO awareness was surprising. Most of our outreach has been to watershed associations and people following MassDEP on social media, so it is possible they have received the knowledge of CSOs through the agency and organizations resulting in high awareness. Most knew why a sewage discharge event occurs, what causes water pollution, and the health risks associated with sewage water exposure. When the respondents were asked about their awareness of CSO signage in their communities the majority reported that they have not seen any signage regarding sewage discharge events.

When asked how often they witness discharge events, most people reported having never seen one. The second most common response was that people notice discharges a few times a year. In the free-response option, some indicated that they have noticed a discharge event whenever it rains. An interesting response to the question regarding knowledge of discharge events was, “I saw notifications from MRWC on Facebook”. About half of the respondents (52.1%) use waterways seasonally. The respondents named a dense and diverse range of waterways they use; it ranged from rivers and reservoirs to ocean beaches. The most popular recreational water activity is boating, followed by swimming. Other responses include wading, walking, and paddleboarding. Many (40.66%) were unsure if they used waterways near a sewage outfall. 90.22% (83 people) use social media, among which Facebook is the most popular with Instagram and Twitter tying for second place. Most respondents use social media either a few times a day or daily. 84 respondents (93%) would be interested in signing up for CSO alerts, while 6 would not be.

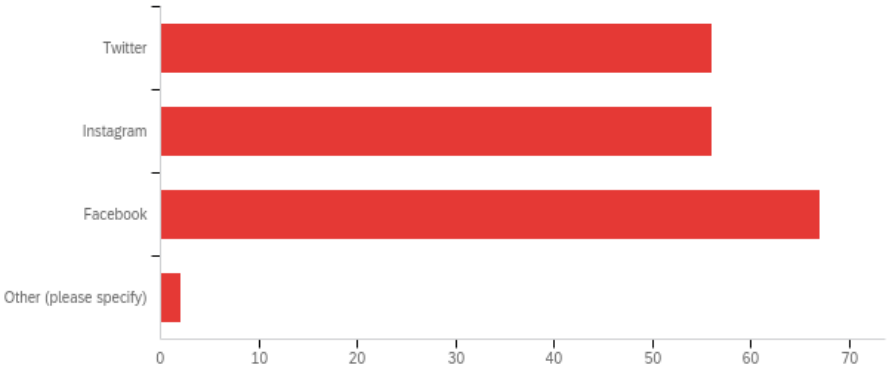
The important conclusions coming from the questionnaire are the lack of signage sightings, preferred social media platforms, and communication platform ratings.

Have you seen any signage at combined sewage outfalls in your community?



Graph 4: Questionnaire responses to the signage question

What social media platforms do you use (select all that apply)?



Graph 5: Questionnaire responses to the social media question

Please rate the communication methods based on your preferences to receive notifications about sewage outfall events.

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
3	Text messages	1.00	5.00	4.14	0.98	0.97	90
4	Emails	2.00	5.00	3.52	0.92	0.85	90
2	Reverse 911 calls	1.00	5.00	3.46	1.25	1.57	83
1	Social media	1.00	5.00	3.16	1.15	1.33	87
6	Other (please specify)	1.00	4.00	2.80	1.47	2.16	5
5	On a website	1.00	5.00	2.25	1.05	1.11	87

Table 1: Questionnaire responses to the media rating question

We focused on the average ratings for each platform. The most popular outreach platform based on the average is text messages followed by emails, reverse 911, social media, and last, website posting.

INTERVIEWS

The interview with the director of the Massachusetts River Alliance, conducted on September 22, 2021, focused on the best ways to communicate with the public about sewage discharge events. The Massachusetts River Alliance is a non-profit organization that forms an alliance with watershed organizations in the New England area. These organizations advocated for the creation of Chapter 322 of Acts 2020. Based on the coded data taken from the interview, signage is one of the most important parts of communicating CSO events. According to the interviewee, signage should be placed at public access points such as boat launches, piers, and designated swimming locations. The sign should contain a design depicting a map of the waterway and show if the public access point is located downstream of CSO outfall locations. The interviewee suggested that a QR code for subscriptions, information about CSOs on the facility website, and one for the MassDEP CSO GIS Map are helpful. According to the representative, the signage must be designed in a way that is easily noticeable, and should potentially include information in languages specific to the locations. The respondent liked the idea of temporary signage. The estimated time for keeping the temporary signs up should be 48 hours, however, this may depend on the speed of the waterway flow and speed of discharge, as well as the volume.

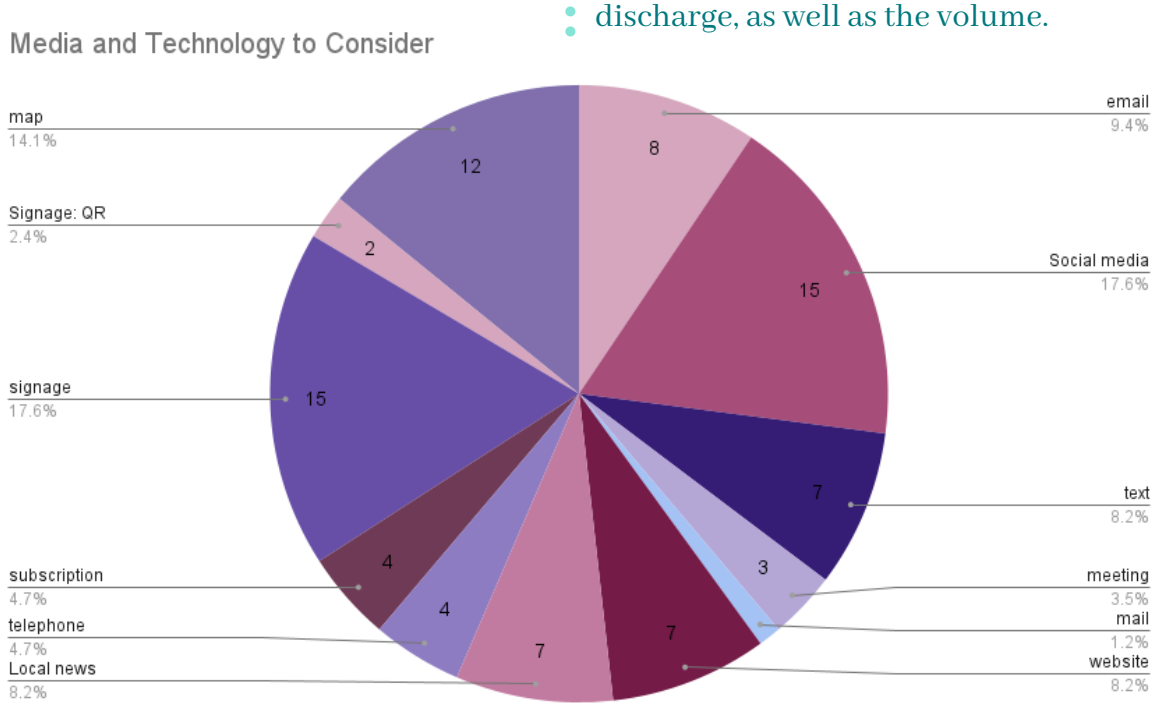


Chart 1: Codes for technologies discussed during the interview

Social media was one of the most discussed topics. However, the representative suggested that the subscription page provides a menu of platform options so that users can decide what platform to opt-in for.

The representative said the frequency of messaging should also be carefully considered, since frequent messaging may be off-putting, especially if the message is sent by text or a reverse 911 call. Some communication platforms mentioned by the representative which were not considered previously were local community Facebook pages, radio stations, newspapers, and the scrolls during weather or news reports on TV stations.

We conducted an interview with a representative of the Merrimack River Watershed Council as a follow-up from the questionnaire. This representative previously worked on the development of a notification system for the organization. This person noted 2 specific platforms used for the notifications; website postings and social media. Social media was said to be the most effective as "We might get a couple 100 people who look at our website when something happens and we'll get 10s of thousands through social media." The two social media platforms used are Facebook and Twitter, with most views coming from their Facebook page that has a following of about 4,000. Other organizations following their Twitter account will retweet and push the information out so more people see the information. During times of the year that tend to have more outfalls and people in the water, between 30 to 40 organizations will retweet their posts. The official also recommended combining all the sewer plant information sent to them into one post for their website, and 1 for their social media, so all the information can be found in 1 spot.

Although, it can be difficult to combine the information because there is no standardized way for the sewer plants to send information, so it needs to be sorted through manually. Some other notification methods being considered by the MRWC are emails, texts, or an app.

Recommendations were made to us by the Merrimack Watershed Council official we interviewed on October 6, 2021. Social media was shown to be the most effective at reaching the greatest number of people, specifically Twitter. Twitter posts can be reposted by other concerned organizations, which helps to further spread information. Website postings reach fewer people than social media, but people are still shown to check there for information. Another recommendation we were given but had not previously thought of was to create an app that people would download, to receive information. It was also recommended that the notifications be location-specific, so people can opt to only receive notifications in the places they are most concerned with. In addition to this, it's important to put all the important information into one place, so people don't have to search.

DATA SUMMARY

The Massachusetts Rivers Alliance representative we spoke with provided feedback on potential communication methods and signage, noting many of the requirements included in Chapter 322 of Acts 2020. The signage requirement at each outfall was mentioned, as the representative made it clear that signage is one of the most effective ways of spreading knowledge at a CSO location. Another important topic discussed was facility website postings when discharges occur, including the Act's required information such as discharge time. Another notification method that was mentioned as an option in both the Act and the interview is reverse 911 calls. While the Act states that the notifications should be issued by email or text, the interviewee listed a couple more media outlets to use: social media, including Twitter, Instagram, Facebook, telephone voice messages, and Mailchimp for emails. The interviewee suggested that subscription pages give users an option for media to sign up for. Some other potential notification platforms mentioned were radio stations, cable news stations, and newspapers, though it was noted that newspapers do not have a wide outreach. (An Act Promoting Awareness of Sewage Pollution in Public Waters)

Similar to the interview, survey and questionnaire responses suggested the effectiveness of social media (especially Facebook) and reverse 911 calls, in addition to emails and text messages. An interesting conclusion coming from the survey and questionnaire is that not enough people see sewage discharge signage, which further emphasizes the importance of placing signs in noticeable locations near and at the CSOs. Questionnaire respondents have also indicated wanting alerts in different languages. The survey and questionnaire, similar to the interview, suggest that meetings, door-to-door communication, and flyers are other communication methods to consider.

Recommendations

In this section, we make recommendations to the Massachusetts Department of Environmental Protection and discharge permit holders (permittees) regarding communicating sewage discharge events to the public. Our recommendations are broken into 4 categories: signage, CSO GIS Map layers, CSO GIS Story Map, and notification system and platforms. Our recommendations are made based on the data we collected through the interview, survey, questionnaire, Chapter 322 of Acts 2020, and additional research we conducted.

SIGNAGE

We recommend that Massachusetts utilize both temporary and permanent discharge signage. Permanent signage should be visibly placed at all outfall locations as required by the Act. We recommend that 2 signs are placed at CSO locations, 1 facing the land and 1 facing the water. An optional format for temporary signage should be accessible for facilities and should be placed at public access points, such as boat access points, piers, and designated swimming areas if downstream from outfalls. All temporary signage must be placed within 8 hours after discharge discovery, and remain at the location for an additional 48 hours [15]. The MassDEP should provide instructions on how to print and where to place temporary signage, along with sign size requirements. [3]

We recommend that the sign acknowledges that a CSO discharge event may occur or is occurring. It should be stated that wet weather events cause discharges and should warn people from recreationally using the water during and immediately following those periods. Both images and text should warn people of the health risks of swimming, fishing, or boating, and ingesting any contaminated water.

Images are important as they will account for any language barriers. 4 separate images could be included, with someone swimming, someone boating, someone wading, and someone fishing, all with a warning sign across it. There should also be a sign suggesting danger in the waters, such as a biohazard symbol, to make sure the reason for avoiding recreational water activities is clear. The sign also requires the CSO ID to be printed so that the specific outfall can be identified quickly. In addition, information about how the public can subscribe to notifications about CSO discharges should be added. Once the notification platform is implemented, a website link, phone number, or email, should be added to the sign to allow people to sign up for the notifications. Since alerts will be issued electronically, the sign includes a QR code for signing up to notifications. We suggest that the CSO notification prompt to register should be written in English first, and then the second most popular language in that community directly below it. We recommend that facilities standardize their signage, or at the least use similar formats, in order to avoid public confusion.

We have created 2 sign templates that we recommend the facilities use or base their signage upon. Chapter 322 of Acts 2020 requires a sign at every sewage outfall location, and the permanent sign that we have created is below in green. The use of bold colors, an all-caps title, as well as large no fishing, swimming, wading, or boating signs are used to grab the attention of the public. The warning signs are also useful to communicate to audience members who lack English proficiency. In order to clarify the reason against engaging in recreational water activities, a biohazard symbol is also added to the sign. One of the suggestions we received from a member of the Massachusetts Watershed Alliance was to add a map showing the nearby CSO locations and public access points.

The map helps the public determine where CSOs are located on the water, and if needed, relocate or cancel any activities. For instance, if a boater is looking for a boat launch and sees the sign, using the map, they can determine if there is an outfall upstream of the public access point. We have also decided to add 2 QR codes. The public can scan one of the QR codes or type in the URL to the local facility website to register for the notification system. The other QR code links to MassDEP's website containing information

Figure 13: The template we created for permanent signage

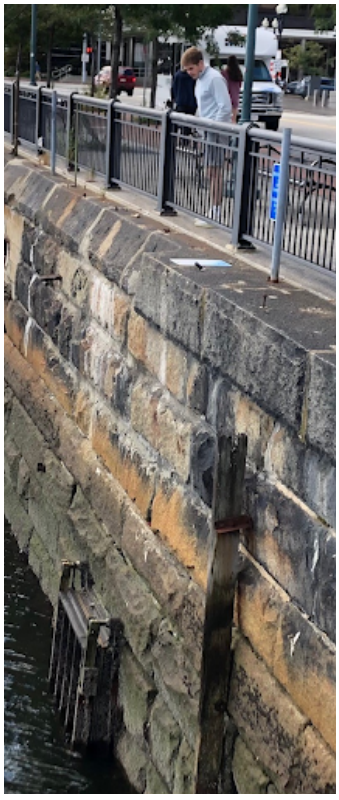


Figure 14: example of ineffective signage placement

Figure 15: The template we created for temporary signage

While doing research on other states who have similar notification requirements, we found that Vermont uses temporary signs at public access points downstream of CSOs. Like the permanent sign, the temporary one's main goal is to notify the public of sewer discharges. Only a few changes were made. Permit holding facilities should provide the date of the discharge event so the public has a reference for the 48-hour recommendation.

As mentioned previously, the temporary sign will be placed at public water access points such as beaches, boat launches, and popular fishing spots. Just like the permanent sign, we recommend that the temporary sign also includes a map so the public can see their location in relation to the outfalls.

GIS LAYER METADATA AND RECOMMENDATIONS

One major deliverable for the project was to help upgrade the current GIS system for CSOs that the DEP offers on their website. The MassGIS CSO map currently displays CSO locations geographically, and if a point is selected, information about the overflow is displayed. This information includes the CSO name, ID number, permit holder, the link to the permit, address, coordinates, receiving waters, and more. We found that the current map is lacking important information and should display additional content.

First, we have found a lack of background information on combined sewage systems. To help with this missing information, we recommend that the DEP add the link to the individual facility websites, specifically the CSO pages. Our WPI team has gathered the links from the facilities overseeing the CSOs and have put them together into a chart. The gathered links can be easily transferred into the current CSO map. On these web pages, the user will find all the background information on CSOs, any recent overflow data, and a prompt for subscribing to notifications. These will be required to be put onto the websites upon the implementation of Chapter 322 of Acts 2020.

Chapter 322 of Acts 2020 requires permittees to establish a metering system for sewer discharge events. Metering is a form of measuring the quantities of discharge. Flowmeter devices are used to measure the velocity of discharges, frequently through sensors. They would usually be installed into or on outfall pipes. Certain devices can measure volumes. The Act requires MassDEP to issue a yearly report of sewage discharges, including the related data, such as volumes. Departments in states like New York and Vermont also provide a listing on sewer discharges on their websites and report the volumes. [41] [49] The amount of discharge is important for the public to know, since higher concentrations of sewage may increase health risks. We recommend that the pop-up table that appears upon clicking on an outfall location has a field called: Metered? And the data should be: yes, no, unsure.

In addition to the recommendations above, we are recommending that the MassDEP adds selectable layers to overlay the GIS map. These layers were chosen from the preexisting Oliver GIS map so the data points and layers will be easily transferred from Oliver to the new map. Some of the layers we are recommending are yet to be published, so we recommend that they are implemented when available. The ability to select different overlays will allow the users to see the relationships between the locations of CSOs and different points or areas of interest. Below are the different layers that we recommend are added to the MassDEP GIS CSO map. [23]

CENSUS 2020 ENVIRONMENTAL JUSTICE POPULATIONS

A major concern of the MassDEP is showing how the environmental justice populations are disproportionally affected by combined sewage systems. Currently, the EJ population layer can be found on the Mass Oliver GIS system and is easily transferable to the CSO map. The EJ layer has shaded locations to show the areas defined as EJ communities. These shaded blocks are color-coordinated to distinguish between the different classifications of EJ communities. Those classifications include minority, income, English isolation, or a combination of the three. The color-coordinated blocks show the relationship between CSO location and EJ populations.

The image on the bottom shows how the CSO locations tend to be surrounded by EJ communities. [23] [24] MassDEP officials noted that the layer portrayed on the map in figure 16 does not contain complete information.

Once the layer of EJ distributions is complete, we recommend that it is implemented on the CSO GIS map, so that the public can be informed about those who are most affected by the sewer discharge issue.

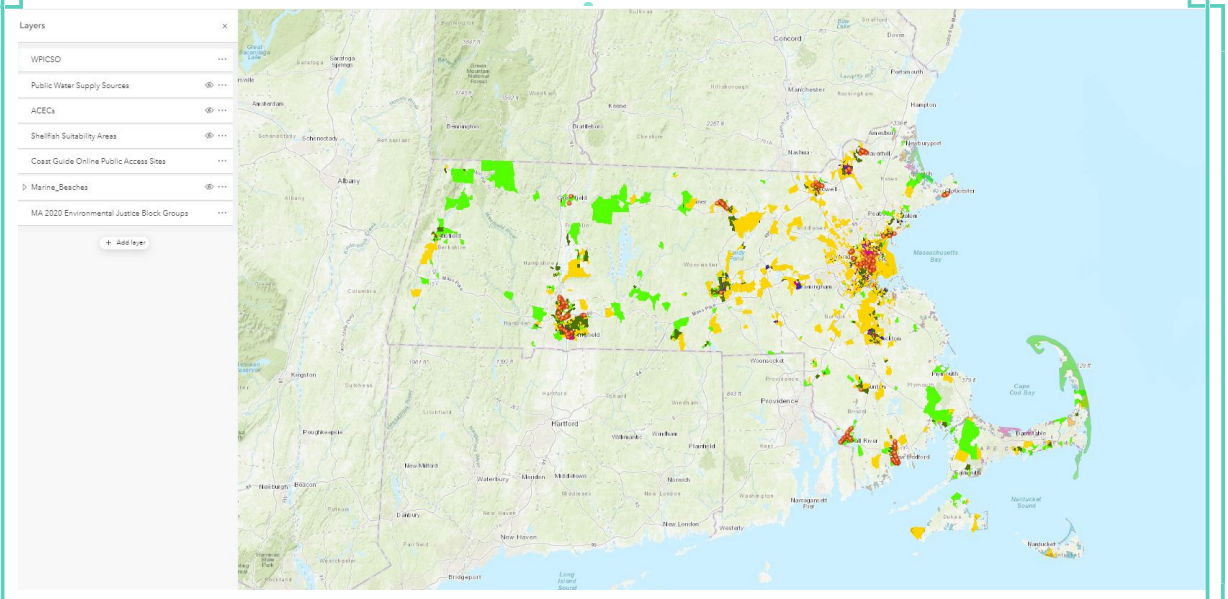


Figure 16: Distributions of EJ communities and CSO locations

MARINE BEACHES

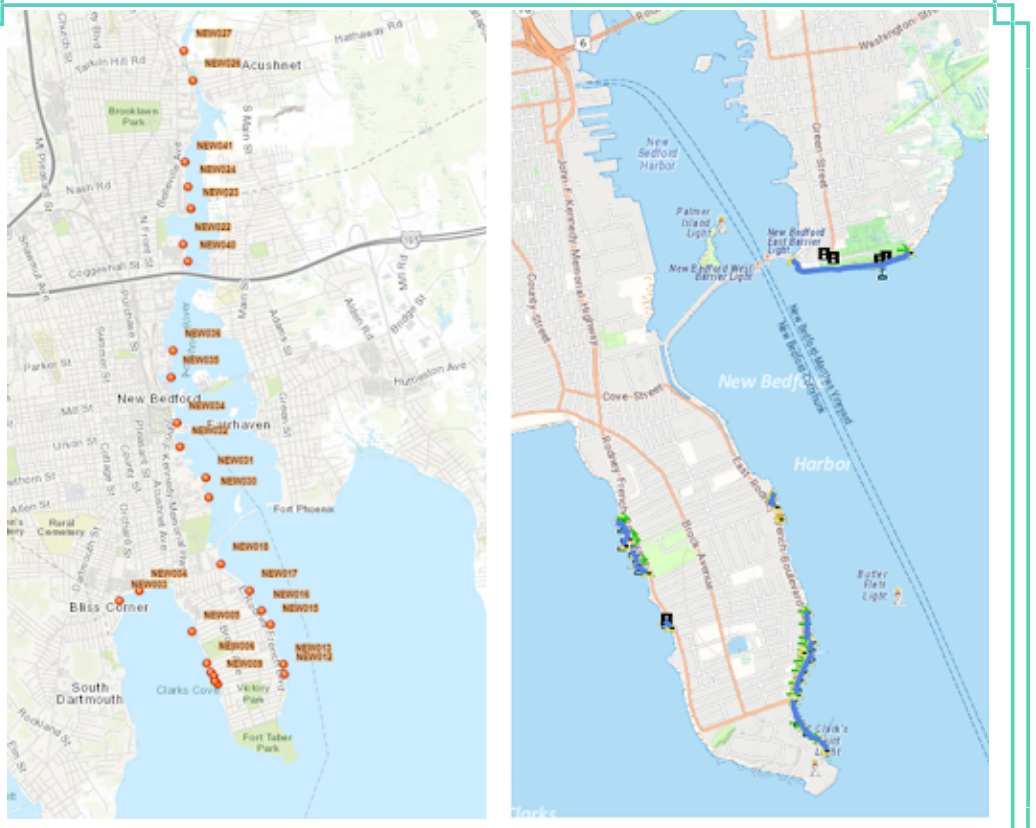
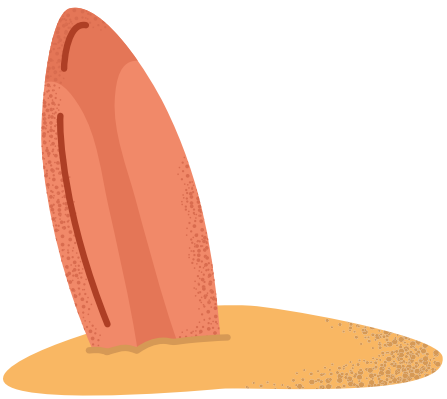


Figure 17: Distributions of marine beaches and CSO locations [28]

The residents use public waters in multiple ways, but swimming provides the most risk and danger of physically contacting or even ingesting raw sewage. The marine beach GIS layer shows all the marine beach locations on the coast. If the beach someone is planning to use is near an overflow, then it would be recommended that they first check the outfall activity near that location. If an overflow was recently reported, then it would be recommended that they do not engage in any water activities at this location. The maps above show the New Bedford region of Massachusetts. Here, roughly 19 CSOs are located upstream and in very close proximity to the marine beaches, some only a couple of hundred feet away. [28]

The CSO GIS map should include a layer of marine beaches so that the residents know if the beaches that they use are located near combined sewage outfalls.



BOAT ACCESS POINTS AND FISHING AREAS

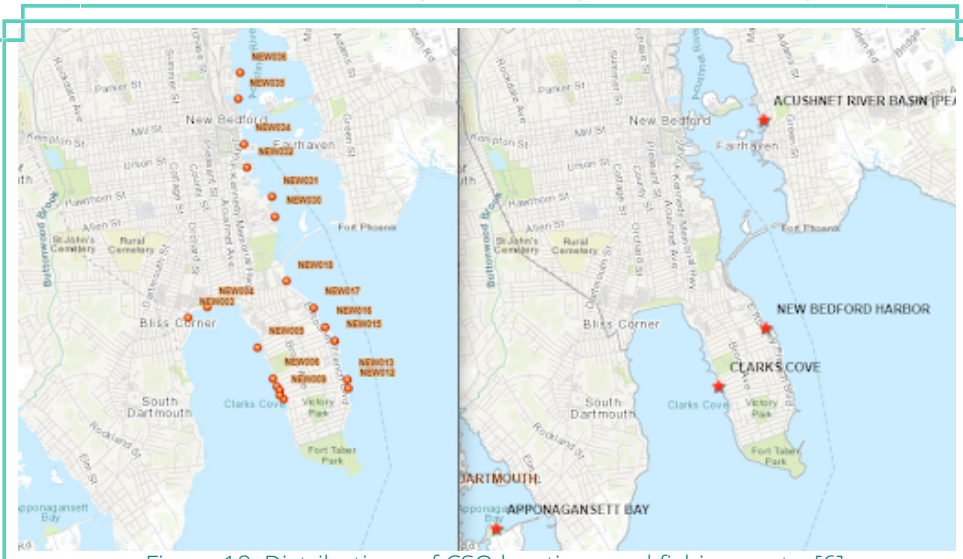


Figure 18: Distributions of CSO locations and fishing spots. [6]

Other ways the public uses the waterways are through boating and fishing. At boat launch sites, the public may wade in the water when launching the boats, and while boating they can come in contact with the water at any time. We have recommended this layer so that the public can easily find the launch and fishing location and determine if any CSO outfalls are located upstream. The layer contains information about types of boat launches: general access, fisherman access, cartop access, canoe access, sport fishing pier, and shore fishing area. There are also codes for different types of fish, such as trout, largemouth bass, and white perch.

We recommend that the GIS map depicts boat and fishing access points so that a boater can determine if launching or fishing at a location is safe. [29]

SHELLFISH GROWING AREAS

Shellfish are a popular food product in the New England Region and are avidly grown and harvested off the shores of Massachusetts. As shellfish filter water for food, they "absorb some of the chemicals and pathogens that are present" in the water column [33]. If shellfish harvesting regions are close to sewage and wastewater overflows, the shellfish can absorb the chemicals from the water. The goal of this layer is to communicate to fishermen that the shellfish they harvest may grow in waters contaminated by CSOs and may not be safe to consume. This layer is not currently available to add to the CSO GIS and will need to be added when the layer is publicly available.[26]

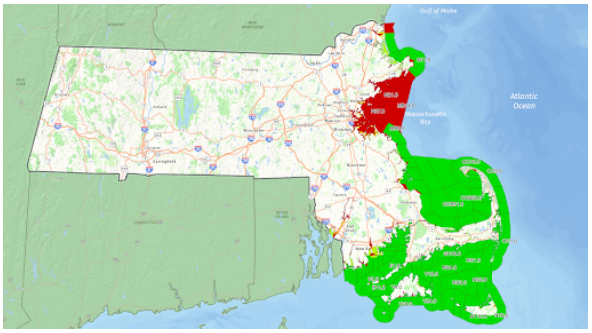


Figure 19: Distributions of shellfish growing areas. Areas in red are where shellfishing is prohibited, and green is approved. [26]

We recommend placing the Shellfish Growing Areas layer onto the CSO GIS map to communicate that harvesting shellfish may be dangerous because they may be growing in CSO locations.

SURFACE PUBLIC WATER INTAKES

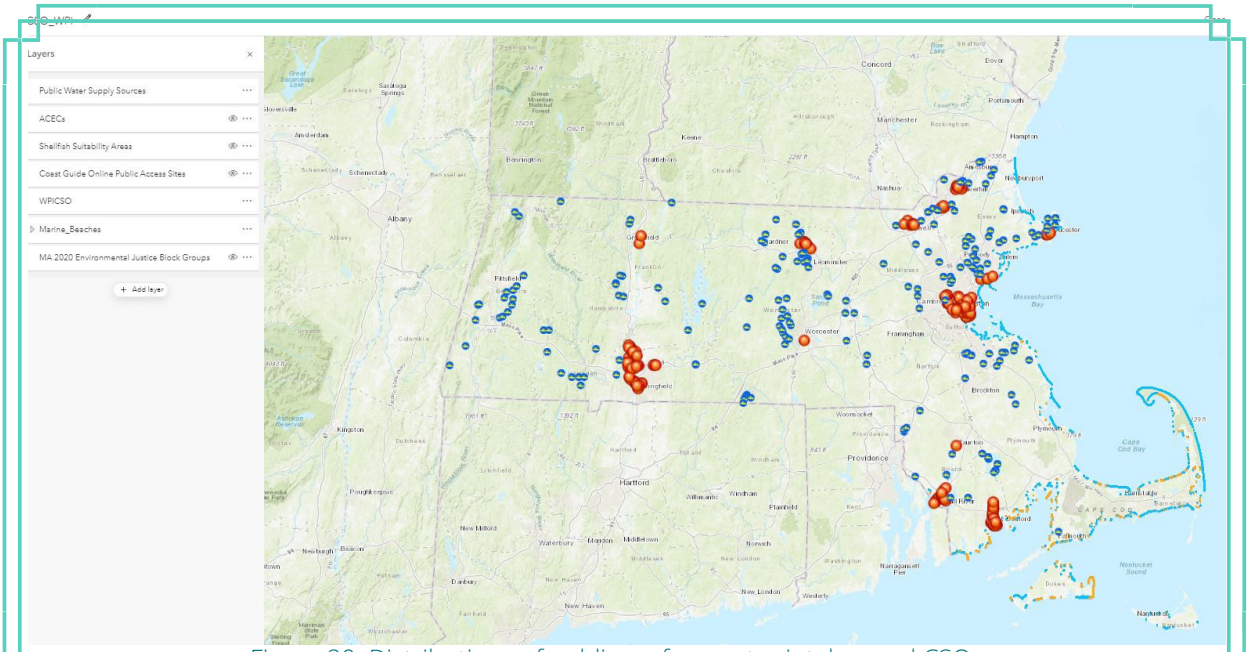


Figure 20: Distributions of public surface water intakes and CSOs

Although water is treated before it is distributed to the public, we think it is important for the public to see if the surface water intake is close to a CSO. In many communities, the water intakes are located in different bodies of water or upstream of CSO. For example, on the Merrimack River in Lowell, surface water intake #3295000-01s is located in close proximity to overflows and is downstream of CSO locations.

We think that the GIS map layer of public surface water intakes should be added to the map so that people are aware that their drinking water may have been contaminated with sewer wastewater before treatment. [30]

Figure 21 and 22: Distributions of public surface water intakes and CSOs [30]

WASTEWATER TREATMENT FACILITY LOCATIONS

Wastewater facilities in Massachusetts have two different permits for water discharges; each location either has a National Pollutant Discharge Elimination System (NPDES) surface water discharge permit, or a MassDEP permitted groundwater discharge. The NPDES permits serve the purpose of managing "wastewater discharges by limiting the quantities of pollutants to be discharged and imposing monitoring requirements and other conditions." [34] The other permit is the groundwater discharge permit, which is important because it ensures that clean water is entering the groundwater. It is critical for public knowledge because "approximately one-half the population of the United States uses groundwater as a drinking water supply. Most groundwater is naturally clean and free of pollutants, but contamination of groundwater can cause serious health effects from harmful bacteria and nitrates." [46] Distinguishing the wastewater treatment facilities based on held permits allows the community to have a better understanding of water quality above or below ground. MassDEP is currently developing the groundwater discharges GIS layer, which includes different treatment plants. The wastewater treatment plant data should be filtered from the layer and added to the CSO GIS map once the layer is published. [45]

We recommend that the water treatment facilities are depicted on the map so that the public is informed that water treatment is in place to ensure that their drinking water is safe to use in spite of sewage contamination.

URBAN AREAS

This GIS layer will be beneficial to help the public visualize where the larger amounts of runoff and sewage accumulate in the water. This will show that urban areas are affected the most by CSOs. [27]

AREAS OF CRITICAL ENVIRONMENTAL CONCERN (ACEC)

ACEC are places recognized for their abundance of unique and valuable resources. These areas require local and regional supervision in order to be maintained. The layer currently provided by the Secretary of Energy and Environmental Affairs (EEA) is only meant for planning purposes and has not been updated since 2009.

We recommend that this layer is developed, portraying up-to-date information on ACEC locations, more specifically the coastal and water ones since it is helpful to know if any ACECs are threatened by CSO discharges. [25]

GIS STORY MAP

We recommend that the Massachusetts Department of Environmental Protection utilizes a GIS story map to provide information about CSO discharges. The topics that should be included are an introduction, combined sewer system (CSS) design and causes of CSO events, treatment, health hazards, CSO mapping tool, public resources, and additional information.

Our recommendations are based on our research. The story map is a useful tool to present information and engage the audience. The Merrimack River has created a CSO story map which lists pages similar to our recommendation: introduction, combined sewer overflows (CSO), flood risk, water quality risk, and land development, Merrimack watershed mapping tool, and additional information. A map is incorporated in most sections, depicting related layers. The mapping tool allows the viewer to select specific layers they would want to see. Our recommendations are inspired by the format of the Merrimack CSO Storymap [18]. However, since this map is a portion of a larger communication system, we decided that it may be helpful to include some points listed in Chapter 322 or Acts 2020, such as communication of health hazards and steps to sign up for CSO alerts, even though they do not pertain to a story map specifically.

Introduction

The goal of the introduction is to make the user acclimated to CSOs and provide useful background information. This includes explaining what a CSO is and groups that are most affected, such as Environmental Justice Communities.

CSS Design and Causes of CSOs

The goal of this section is to explain why wet weather events cause discharges; this section should contain an infographic that explains this. This section would also provide the user with the causes of CSOs, such as precipitation, and include how certain weather events lead to overflows. This section should also include the map of CSO outfall locations in Massachusetts.

Treatment

The treatment section will explain the treatment process of discharges to the user. It may be helpful to show a map of CSO outfall locations along with locations and images of the Treatment Plants.

Health Hazards

The section should communicate any health-related issues which could result from coming into contact with contaminated waters and shores. It should be made clear that potentially ingesting contaminated water through swimming, wading, fishing, or boating could result in illness. This section could depict images of signage that warns the public from engaging in those activities during and following a discharge event.

CSO Mapping Tool

This section should include a map of CSO locations and provide the user with the option to view other layers, including but not limited to the layers we recommended to include in the current MassDEP CSO GIS Map. These layers include EJ communities, CSO locations, public access points, CSO metering, public water supply, marine beaches, urban areas, treatment facilities, and shellfish growing areas.

Public Resources

This section should explain the process of signing up for CSO notifications along with a link to the CSO notification platform. A link to the facility websites in charge of CSOs should also be included. A list of any media that reports such events, such as news stations, will also be added.

Additional Information

The final section, labeled as the additional information section, would add any final information that may be helpful to the user. All sections should contain images, such as signage examples or sewer pipes.

All sections should contain images, such as signage examples or sewer pipes.

Additional story map criteria have been recommended by MassDEP officials directly. . Some aspects that will add to the story map include images of the outfalls, sample CSO signage, and interactive maps. It may be helpful to list which towns contain outfall locations. Other useful additions that will help further explain the process of reporting discharges to the public include permit links and associated web pages. In the future, adding a list of outfall closures will also prove to the public that steps are being taken to prevent discharge events. Including a map with the outfall locations where the discharged water is treated prior to being released will also be important for public knowledge. [45]

We created an infographic meant to be used in a CSO story map. The infographic has 2 figures, with figure 1 representing normal weather and figure 2 representing wet weather. The aspects of the CSS included downspouts, storm drains, weir walls, treatment plants, water bodies, sewage, stormwater, and the sewer pipes of the CSS. The first figure shows that during normal weather patterns, all sewage and stormwater flows to the treatment plants via the sewer pipes. The second figure shows that during extreme or abnormal precipitation, the increase of water causes the stormwater and sewage to be discharged into water bodies. We recommend that this infographic is used in the CSS and CSO section of the story map, as it is simple yet explains how CSO discharges occur.

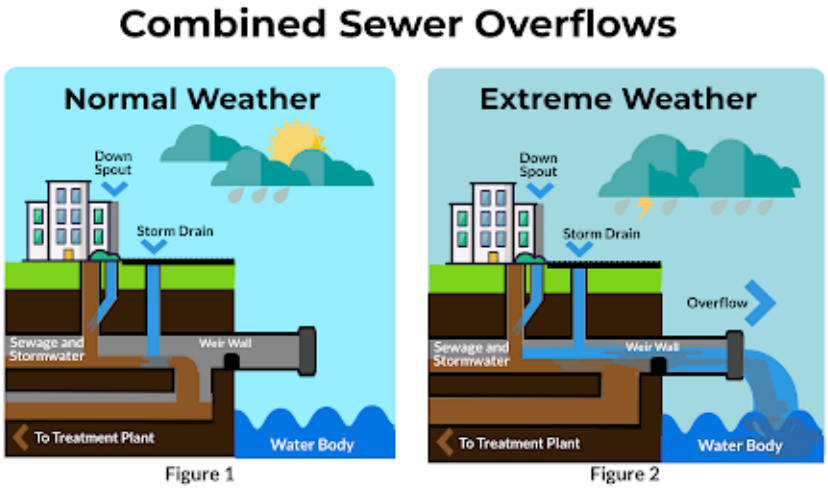


Figure 1 Figure 2

Figure 23: CSS infographic

NOTIFICATION SYSTEM

The Act requires permittees to issue text and/or email alerts to the public. Based on our research from the survey, questionnaire, interview, and case studies of CSO alert systems in other states, we are making recommendations in addition to the Act requirements. Based on interview suggestions, we believe that it would be best for the users to opt-in to a notification system, as opposed to opt-out. Upon subscription, the user should get a choice of whether they want to be notified by email, text, Whatsapp messages, social media platforms, or reverse 911 calls. If the permittee oversees outfalls in several cities, users should get an option to subscribe to receive notifications in a specific city of their choice or simply all outfall locations monitored by the facility. Notifications should be available in at least 3 of the most spoken languages in the facility region.

A member of GreenRoots, an EJ organization in Chelsea, MA, which works with local EJ populations, noted that many community members lack access to the internet and technological devices [32]. The organization's outreach to the community consists of public gatherings and meetings, flyers, and door-to-door communication. Once the notification system and signage are fully implemented, we recommend that facilities reach out to EJ organizations and watershed associations to hold public meetings in EJ communities. The purpose of the meetings should be to identify outfall locations for the community residents as well as outfall signage in these areas, discuss weather-related causes and health risks of CSOs, explain the notification system, and provide the public with any additional information the facility believes is necessary. When it comes to reporting discharge events to news stations, permittees should reach out to at least one news station in a language other than English. We recommend that TV stations list the discharge events on the scroll at the bottom of the screen. All alerts should clearly state what the users must refrain from doing (swimming, boating, fishing, shellfishing, wading) and the duration (for example, 48 hours). Lastly, the facilities and MassDEP should keep a public list of all discharge events on their website that will be updated live. The website postings should include date/time, location, duration, volume, treated state, causes of discharges.

Conclusion

Massachusetts' outdated combined sewage systems are contaminating public waterways with raw sewage during wet weather. The Massachusetts Commonwealth was not notified of the overflow events until Chapter 322 of Acts 2020 was passed requiring the MassDEP to notify the public. We helped MassDEP implement the communication system while meeting the Act's requirements. Our team recommended a communication system to the DEP that will meet the needs of the affected communities in Massachusetts. Through survey and questionnaire, interview, research, and our partnership with MassDEP, we worked to ensure our goals are completed.

We mapped out the stakeholders involved in the CSO issue to understand the complex relationships between the involved parties. We surveyed the environmental justice organizations and the public. We recommended layers to a GIS map and pages to include in a future story map. Our group researched the communication systems for CSOs established in New York, Vermont, and Connecticut. Our team developed template signs. Through our efforts and research, our project will bring Massachusetts one step closer to a complete CSO alert system.

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