Chemical Safety and Climate Change Resiliency

WPI

An Interactive Qualifying Project Report

Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the Degree of Bachelor of Science

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Date Submitted:
October 13, 2022

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Abstract:

This project was conducted alongside the Massachusetts Office of Technical Assistance and Technology (OTA) in order to evaluate how Toxics Use Reduction Act (TURA) filers are preparing for climate change. Through this data collection, OTA can improve their trainings so they are better adapted to what companies need. We found that many companies are complying and keeping up to date on regulations, and with emergency preparedness planning. However, many TURA filers are not accounting for or are unaware of climate change issues, which may lead specific facilities at risk to climate change based chemical accidents. Through improved OTA trainings, TURA filers can keep their facilities and the surrounding communities safer.

Acknowledgements:

We would like to thank OTA for allowing us into their staff for seven weeks, and sharing their wonderful expertise in the world of climate resiliency. We would like to thank OTA stakeholders for making time in their busy schedules to sit down for interviews with us. The information gathered from these interviews was very insightful, and aided us in completing this project. We would like to thank Corey Dehner for stepping in and providing us with her advice as our stand-in advisor, despite how busy she has been with her own work. She gave us valuable feedback that increased not only our writing skills, but our knowledge on professional presenting. We would also like to thank Derren Rosenbach for giving us the basics of IQP and for guiding our research in the right direction through our ID 2050 class.

We would like to thank our families for supporting us through this time in our lives. And finally, we would like to thank Professor Blake Currier, for all that he has done these past 14+ weeks. His tenacity and enthusiasm helped us push forward to further and new heights to complete this project to the utmost of our abilities. We cannot thank everyone enough for their emotional support and their investment to make this project as successful as it is.

Executive Summary:

Climate change is creating massive impacts around the world, but certain communities have a different reason to fear these climate disasters. Communities that house manufacturing facilities that produce or use toxic materials, are especially vulnerable to such risks concerning climate change and climate disasters. Like the rest of the world, Massachusetts is dealing with the consequences of climate change, such as rising sea levels, fluctuating temperatures, and larger-scale natural disasters. Manufacturers that use toxic chemicals are a significant contributor to large-scale chemical disasters due to the vast quantity of chemicals in use and storage. Containing these chemicals to keep the environment, workers, and the surrounding population safe should be of the utmost importance to any facility dealing with toxic substances.

The Toxics Use Reduction Act, or TURA, created by the state law MGL Chapter 21 I, "requires Massachusetts companies that use large quantities of specific toxic chemicals to evaluate their operations, plan for pollution prevention, and report on the results each year" (TURA: MGL c.21I). This is a law specific to Massachusetts that applies to companies and facilities that manufacture, process, or otherwise use chemicals listed as toxic or hazardous substances on the state's list of Toxic or Hazardous Substances (301 CMR 41) above reportable threshold values (Massachusetts Government (2), n.d.) and that are certain Standard Industrial Classification or SIC codes with more than ten employees. These companies are required to submit an annual report to MassDEP about the listed toxic substances they're using; they have to pay a fee; and every two years they have to create a Toxics Use Reduction plan. The TUR plan is kept on site for inspectors to review, and companies are required to submit a summary of their plan to MassDEP (MassDEP, n.d.). Although toxics use reduction planning is a worthy exercise throughout Massachusetts, these plans do not address everything, especially regarding climate change preparedness. The Massachusetts government is aware of risks such as floods and hurricanes, and has state agencies like the Office of Technical Assistance and Technology (OTA) that provides assistance to companies that file under TURA.

Methodology

The goal of this project was to evaluate Toxics Use Reduction Act (TURA) filing companies' needs related to chemical safety and climate resiliency. In order to accomplish this goal, we examined OTA's training materials to see what information was present on the current materials. We then gathered information on current TURA-filing companies by developing and

distributing a survey. We also conducted interviews to assess the needs of TURA-filing companies relating to climate change. Through our data, we worked to aid OTA by providing insight on what facilities are doing well and what could still use some work. By improving OTA, our goal was to offer information to OTA so they can continue to work with manufacturing companies to keep factory workers, first responders, and civilians around TURA filers safe. We also hope to learn how companies prepare for climate change, and how OTA can make meaningful recommendations to companies in this area.

The objectives for this project were: Evaluate how Toxics Use Reduction Act (TURA) filers are preparing for climate change throughout Massachusetts; Seek out information from OTA stakeholder companies for a deeper understanding of consumer needs; Analyze data and develop recommendations on how to meet the existing chemical safety and climate change preparedness needs of TURA filers / toxic users. In order to accomplish these objectives, we distributed a survey in order to assess TURA filers' current needs related to chemical safety and climate resiliency so that OTA can provide tailored training and technical assistance relevant to their needs. This survey was sent to companies in Massachusetts that file under the Toxics Use Reduction Act, or TURA. Secondly, we conducted interviews with stakeholder companies of OTA. These companies were not necessarily TURA filers, but had experience with OTA in the past. From this, we gained a deeper understanding of what these stakeholders wanted out of OTA. These interviews also allowed us to hear personal feedback that may not have been possible through a survey, as they were representatives of agencies and organizations that OTA has collaborated with.

Finally, we analyzed the survey and interview data. Using this data analysis, we developed 3 recommendations for changes to the training materials based on up-to-date knowledge of company needs. The main deliverable of this project will be to provide OTA with the survey results and interview information so that the OTA can improve their practices. We sent the survey out to 397 companies. By the time the survey was closed on September 30th, we had a total of 56 responses, with 47 agreeing to take the survey and 39 of those completing the full survey

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Glossary & Definitions:

CHMM: Certified Hazardous Materials Manager

EHS: Environmental Health and Safety

EJC: Environmental Justice Community

An environmental justice population is a neighborhood where the annual median household income is 65 percent or less of the statewide annual median household income, minorities make up 40 percent or more of the population, 25 percent or more of households identify as speaking English less than "very well" and/or minorities make up 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. (Massachusetts Government (1), n.d.)

EPA: Environmental Protection Agency

EPCRA: Emergency Planning and Community Right to Know Act

GAO: United States Government Accountability Office

LQTU: Large Quantity Toxic Users

L/REPC: (Local) Regional Emergency Planning Committee

NOAA: National Oceanic and Atmospheric Administration (NOAA)

OTA: Office of Technical Assistance and Technology

SIC: Standard Industrial Classification

TURA: Toxics Use Reduction Act

TURI: Massachusetts Toxic Use Reduction Institute

TURP: Toxics Use Reduction Planner

USGCRP: United States Global Change Research Program

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1. Introduction

Over the last century, climate change has become an ever-increasing concern that cannot be ignored. Impacts from climate change include but are not limited to long-term shifts in temperatures, more powerful and dangerous natural disasters, and coastal flooding. These impacts are occurring all around the world, but certain communities have a different reason to fear these climate disasters. For example, communities with facilities that produce or use toxic materials are especially vulnerable to such risks. A climate disaster occurring at any of these facilities, such as a hurricane or flood, may pose extreme risks to the surrounding area. This is because climate risks can cause industrial accidents such as releasing toxic chemicals to the environment or chemical explosions. This could be very harmful to surrounding communities, many of which are in Environmental Justice neighborhoods. “An environmental justice population is a neighborhood where the annual median household income is 65 percent or less of the statewide annual median household income, minorities make up 40 percent or more of the population 25 percent or more of households identify as speaking English less than "very well" and/or minorities make up 25 percent or more of the population” (Massachusetts Government (1), n.d.). As these communities are already underserved in Massachusetts, a spill or accident in an EJ neighborhood would be disproportionately catastrophic.

In 2020, ethyl acetate made up 7,856,251 pounds of total chemicals used, and 8,837,622 pounds were created as a byproduct (Massachusetts Toxic Use Reduction Data, n.d.). According to Standard Industrial Classification (SIC) codes, the industry that used Ethyl Acetate the most in 2020 was paper coating and laminating products (Massachusetts Toxic Use Reduction, n.d.). Ethyl Acetate is a dangerous chemical that, with extended high levels exposure, can cause employees to feel dizziness, lightheadedness, and even passing out. Ethyl Acetate is a flammable liquid and a fire hazard (New Jersey Department of Health and Senior Services, 2002). Other chemicals mentioned, like Ammonia, are even more harmful. Some side effects of Ammonia exposure include “a burning sensation of the eyes, nose, and throat, accompanied by lacrimation, rhinorrhea, and coughing; Upper airway swelling and pulmonary edema may lead to airway obstruction” (Agency for Toxic Substances and Disease Registry, 2017). According to Massachusetts Toxic Use Reduction Institute (TURI), 420,600,038 pounds of hazardous chemicals from the Toxic or Hazardous Substances List (301 CMR 41) were either

manufactured, processed, or used in Massachusetts in 2020 (Massachusetts Toxic Use Reduction, n.d.). Although these numbers may be alarming, 2020 produced the lowest amount of hazardous chemicals in Massachusetts in over 30 years (Massachusetts Toxic Use Reduction, n.d.). This is partly due to the effort put into Massachusetts's Toxics Use Reduction Act.

The Toxics Use Reduction Act, or TURA, created by the state law MGL Chapter 21 I, "requires Massachusetts companies that use large quantities of specific toxic chemicals to evaluate their operations, plan for pollution prevention, and report on the results each year" (TURA: MGL c.21I). This is a law specific to Massachusetts that applies to companies and facilities that manufacture, process, or otherwise use chemicals listed as toxic or hazardous substances on the state's list of Toxic or Hazardous Substances (301 CMR 41) above reportable threshold values (Massachusetts Government (2), n.d.) and that are certain Standard Industrial Classification or SIC codes with more than ten employees. These companies are required to submit an annual report to MassDEP about the listed toxic substances they're using; they have to pay a fee; and every two years they have to create a Toxics Use Reduction plan. The TUR plan is kept on site for inspectors to review, and companies are required to submit a summary of their plan to MassDEP (MassDEP, n.d.). Although this greatly reduced the uses of toxic chemicals in facilities throughout Massachusetts, these efforts have not been enough, especially regarding climate change preparedness. The Massachusetts government is aware of such risks and has state offices like the Office of Technical Assistance and Technology (OTA) that provide assistance to companies that file under TURA, who manufacture, process, and use toxic chemicals.

There are currently about 400 companies that fall under the law's requirements. The Massachusetts Office of Technical Assistance and Technology (OTA) exists specifically to provide free and confidential technical assistance to companies that are covered under the Massachusetts Toxics Use Reduction Act (TURA). Our project focused on TURA-filing companies to evaluate the current state of OTA's training materials by performing a survey and interviews to assess the needs of TURA-filing companies relating to climate change. Through our data, we hope to improve OTA by providing insight on what facilities are doing well and what could still use some work. By improving OTA, our hope is to keep factory workers, first responders, and civilians around TURA filers safe. We also hope to learn how companies prepare for climate change, and how OTA can make meaningful recommendations to companies in this area.

2. Background & Literature Review

2.1 Major Information of Massachusetts

The population of Massachusetts consists of approximately 6.9 million people as of 2020 (United States Census Bureau) encompassing an area of about 10,565 square miles. Within that area, Massachusetts possesses a total of 18 rivers and over three thousand lakes, which makes flooding a real possibility. Additionally, it is a coastal state with many residents living along the coast, especially in the largest city in all of New England, Boston, where we worked primarily for this project.

2.1.1 Climate and Environment of Massachusetts

Massachusetts has a continental climate, with frigid winters and warm to hot summers yearly. While very dangerous tornadoes and earthquakes are rare, thunder and snow storms are pretty common during their respective seasons (Climates to Travel, 2020). Like the rest of the world, Massachusetts is dealing with the many consequences of climate change, such as rising sea levels, fluctuating temperatures, and larger-scale natural disasters.

As a coastal state, Massachusetts has many cities, such as Boston, that are vulnerable to rising sea levels which will leave significant parts of the city submerged under water (Broccoli et al., 2018). "By 2100, under a worst-case scenario where emissions keep increasing, researchers estimate that sea levels around Boston could rise by 6.4 feet" (Noor, D., 2022). Global temperature increases also cause rapid shifts in extreme climate conditions. Because of this, Massachusetts' summers will only get hotter as the global temperatures increase (Stang, 2015). Counter-intuitively, due to climate change, Massachusetts' winters are likely to get colder rather than warmer (McGrath, 2021). We will also see increased precipitation during winter, as the increased temperature in the atmosphere will cause more snow to fall (McGrath, 2021).

For example, just look at the disastrous winter storm that occurred in Texas in February 2021, a state well known for its hot summers and mild to warm winter. This storm left 2.7 million homes without power, extreme pull-ups on highways, and shortages of necessities over a week-long period. (Reader et al., 2022). The most significant contributor to this disaster was the complete lack of preparation to account for a storm of this magnitude. Weather of this scale is

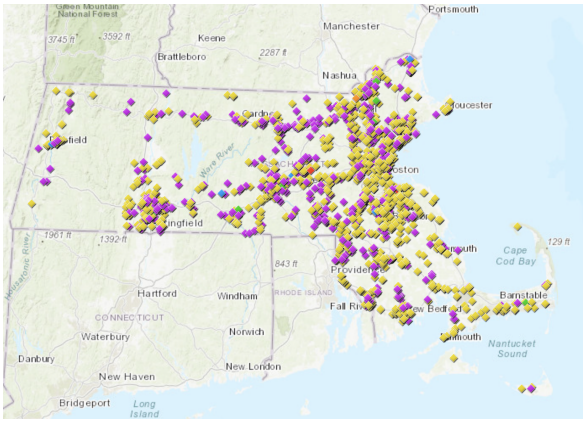
commonplace in many other parts of the country, but since Texas was not prepared for an event like this, the entire state went into a crisis that could have been avoided with better planning. Specifically, Texas was not equipped with electrical generators and the correct infrastructure to operate in such a frigid environment (Carpenter, 2021). This is just one example of why climate change preparedness is essential for keeping our communities safe.

That being said, large-scale power outages aren't the only way climate change can leave an entire region in crisis. Without receiving proper training regarding toxic chemical storage, use, manufacturing, or processing in relation to the impact of climate change, we leave communities at risk of exposure to hazardous substances and may leave some areas uninhabitable for decades.

2.2 Toxic Chemical Use

The Environmental Protection Agency (EPA) defines hazardous chemicals as those that can pose health risks to people and physical risks to the environment. Chemicals that are toxic, irritants, cause damage to muscular membranes, and more, pose serious health risks to people that are exposed to them (Environmental Protection Agency). Chemicals that are combustible, flammable, unstable, water-reactive, etc., can cause severe environmental damage if not dealt with appropriately (Environmental Protection Agency). Fuels, such as oil and gasoline, may be hazardous in specific environments. Containing these chemicals to keep the environment, workers, and the surrounding population safe should be of the utmost importance to any facility detailing with toxic substances. Nations around the globe have invested in the foundation of organizations to help improve or most importantly reduce the use and storage of possibly toxic substances. One of the entities that take care of this issue in the state of Massachusetts is the Office of Technical Assistance.

Figure 1: Map of Massachusetts's Large Quantity Toxics Users



2.2.1 Office of Technical Assistance and TURA

In 1989, the Massachusetts Legislature passed the Toxics Use Reduction Act or TURA. This act was established to regulate and monitor the use of toxic chemicals from specific facilities in Massachusetts. The Office of Technical Assistance and Technology, or OTA, was founded in 1989 to help provide free and confidential toxics use reduction assistance to TURA-designated Large Quantity Toxic Users (LQTU) in the state of Massachusetts (Ansaldi, 2011). This includes facilities that use TURA-listed chemicals, employ ten or more workers, and manufacture in specific industries. TURA-listed chemicals include those used in manufacturing processes, not explicitly included in the final products. Each company must complete a Toxics Use Reduction Plan every other year as well as file a plan summary and pay a fee to MassDEP. Since TURA was established, use of toxics in Massachusetts have reduced. OTA works with manufacturers to reduce their use of toxic chemicals or substitute safer chemical alternatives in order to prevent pollution and reduce the risk of exposure to harmful chemicals.

2.2.2 Office of Technical Assistance Training Materials

The exact method for storing hazardous chemicals from the Toxic or Hazardous Substances List (301 CMR 41) varies on several factors, such as location and chemical characteristics. Some commonly utilized practices are the frequency at which storage areas may be reviewed or safety precautions should a chemical become contaminated. Although these practices occur in other states, some of the specific policies are already in place in Massachusetts. Massachusetts is regulated by M.G.L Chapter 21C: Massachusetts Hazardous Waste Management Act. This law established a hazardous waste advisory committee, which “reviews the development of standards, rules, and regulations for waste management practices” (The 192nd General Court of the Commonwealth of Massachusetts). This law also has several sections, covering topics such as; “Collection, transportation, storage, etc., of hazardous waste; prohibited acts,” “Collection, storage, etc., of hazardous waste at generation site; regulations,” and “Entry of premises; warrants; enforcement of the law,” "Disclosure of information,” and more (The 192nd General Court of the Commonwealth of Massachusetts). The amount of personal liability, strict regulation, and accessibility to facilities for authorized agents give facilities in the state of Massachusetts very clear guidelines to follow. There are other regulations

that facilities may need to follow such as Tier II and RCRA. They manage the storage and usage for many of the chemicals manufacturers may be accustomed to using. These regulations, some of which fall under the EPA program, cover chemical safety that may often be bypassed by facilities.

OTA currently has slides for training about chemical safety issues. These resources cover the topics of "OTA Resources & Climate Change Preparedness," "Emergency Planning 101," "Chemical Incident Response," and more (Office of Technical Assistance and Technology). They are used to advise organizations on good chemical safety practices and how to account for any climate change impacts. The OTA presents these slides during their workshops and presentations to facilities that fall within TURA regulations but are available to the public on their website.

A Local or Regional Emergency Planning Committees (L/REPC) are local community-run committees that are created out of the federal Emergency Planning and Community Right to Know Act (EPCRA). "This involves developing emergency response plans and educating the community about chemical facilities and the actions that could be taken if there is a chemical accident" (Office of Technical Assistance and Technology). As the state does not mandate these L/REPC[2]s, it is the local communities' responsibility to reach out to facilities. Facilities deemed as Toxic Users, those that deal with a large number of toxic materials, are obligated to participate in L/REPC to ensure they comply with regulations and emergency response plans (Office of Technical Assistance & Technology).

OTA provides a Toxic Users and Climate Vulnerability Factors map, which displays toxic chemical users in Massachusetts and their climate vulnerability factors. This allows facilities to track whether they are at risk of floods, storms, hurricanes, or other possible climate disasters (https://www.mass.gov/service-details/mapping-toxics-in-communities-and-assessing-climate-vulnerability).

Lastly, the Toxics Use Reduction Institute (Toxics Use Reduction Institute, n.d.) provides grants, training, and resources for reducing worker safety and toxic use. OTA provides training materials to help prepare businesses for the effects of climate change on chemical safety (Office of Technical Assistance and Technology). This includes providing businesses and facilities with tools to "prepare for severe weather events, comply with emergency planning requirements, and incorporate toxics use reduction into their emergency plans to avoid potential chemical releases or accidents" (Office of Technical Assistance & Technology).

2.3 Impacts of Climate Change

From 1993 to 2003, sea levels rose 3.1 ± 0.7 millimeters per year (Kirshen et al., 2008). Combined with increased precipitation, rising sea levels cause more frequent flooding across coastal areas. Storm surges in the Boston Harbor are the largest contributor to flooding in the greater Boston area. According to the National Oceanic and Atmospheric Administration (NOAA), these storm surges can result in rising tides being two feet higher than usual (NOAA, 2022). The higher tides make it easier for the coasts to get flooded, damaging infrastructure, transportation systems, and wetlands near the coast. "Long-term sea-level rise is the main driver for accelerated flooding along the US coastline; however, under otherwise stationary conditions, changes in the joint distributions of storm surge and precipitation associated with climate variability and change also augment flood potential" (Bender, J. et al., 2015).

In a study conducted by Alexander Nauels, predicted sea level rise was based on several factors, including thermal expansion, glaciers, solid ice discharge and surface mass balance for Greenland and Antarctica, and land water (Nauels et al., 2017). These factors were changed to represent different possible outcomes of climate change, and the study produced four separate scenarios. These scenarios all have a median range for the year 2100 and for the year 2300. The study predicts that by the year 2100, the sea level will rise between 0.35 and 1.09 meters (Nauels et al., 2017). The projections also show that by 2300, the sea level will rise between 0.80 and 6.82 meters (Nauels et al., 2017). The worst-case scenario could spell the end for several coastal regions around Boston.

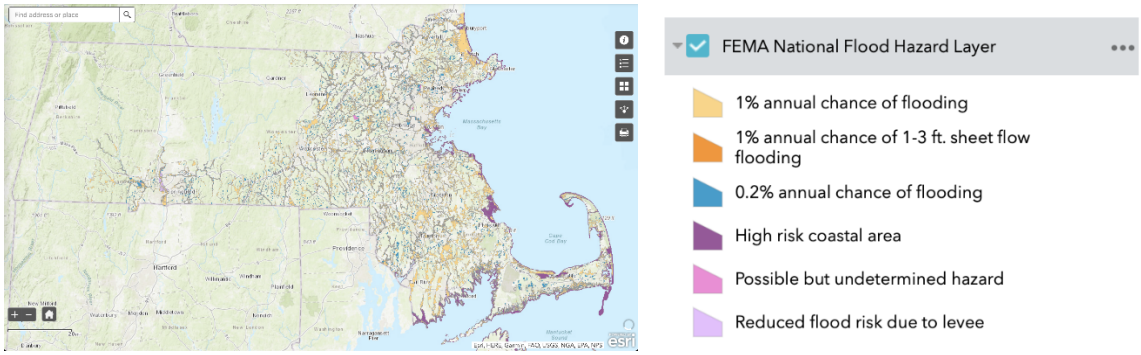


Figure 2: Flood hazard map of Massachusetts

Aside from sea level rise, air temperature is another negative side effect of climate change affecting the globe. A study conducted by the U.S. Global Change Research Program (USGCRP) states that compared to average temperatures across the United States from 1986 to 2015, the average temperatures in Massachusetts will increase by two to four degrees Fahrenheit by 2065 (Avery et al., 2018). The same study found that temperatures will increase between four and eight degrees by 2100, based on the same averages. The same study also states that, since the turn of the century, the average air temperature has risen by 1.8 degrees Fahrenheit (Avery et al., 2018).

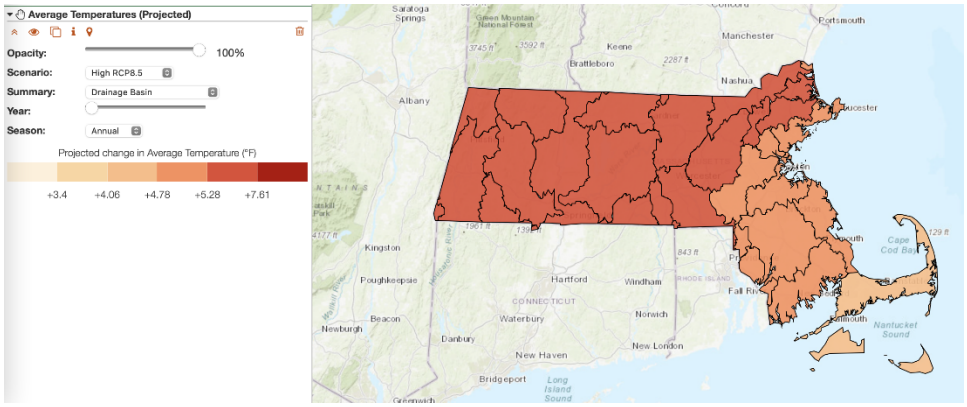


Figure 3: Map of the predicted average temperature increase in the state of Massachusetts by the year 2050.

Precipitation is another natural process that is affected by climate change. According to the same study conducted by USGCRP, there is an expected increase in precipitation in Massachusetts. The following percentage increases are based on averages from 1986-2015. In the summer and fall seasons, the percentage change in precipitation would go up between zero and five percent. In the spring, Massachusetts will see ten to fifteen percent more precipitation. Winter appears to be the most considerable difference in precipitation, with the study stating that precipitation will increase by fifteen to twenty percent (Avery et al., 2018). These statistics represent the predicted outcome between the years 2070-2099.

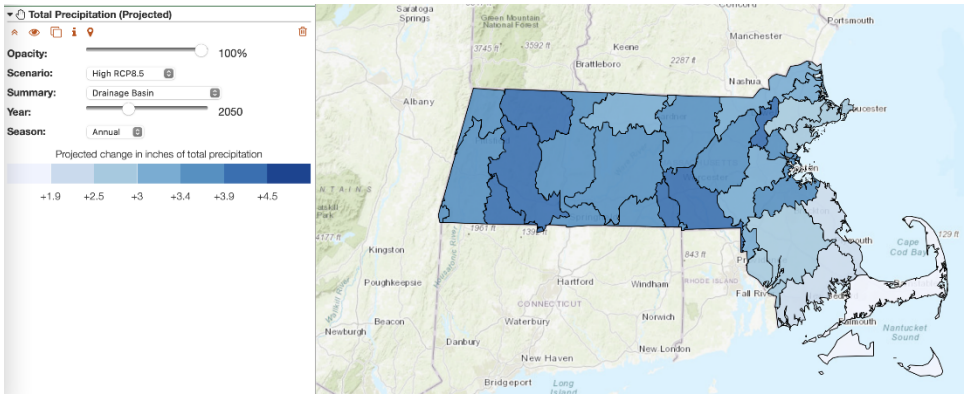


Figure 4: Map of the predicted average precipitation change in the state of Massachusetts by the year 2050.

The NOAA Sea Level Rise and Coastal Flooding Impacts map allows us to input potential sea levels and see what regions will be impacted the most by these changes (NOAA). Based on the best case scenario from the Nauels study (0.35 meters of sea level rise by 2100, 0.8 meters of sea level rise by 2300), we can set the water level to be 0.35 meters. At this height of sea level, the regions that would be affected are as follows; Winthrop, Revere, Chelsea, Everett, Malden, Medford, Cambridge, Roxbury, Brookline, Quincy, Weymouth, Dorchester, Boston, South Boston, and East Boston (NOAA). If we were to raise the sea level up to 3 meters, regions such as Somerville, Charlestown, and Belmont would be added to the list (NOAA).

As for air temperatures and increased precipitation, these changes would affect the entire state of Massachusetts. There may be slight differences based on geographical location, but the majority of regions near the Boston Harbor region would face similar impacts (Avery et al., 2018).

The most obvious change to these regions would be the amount of flooding that occurs in these regions. While there are already floods that happen in some of these regions, the rise in sea level would eventually start to affect the rivers surrounding these regions as well. Specifically, the Charles River, Chelsea River, and Mystic River would all see excessive amounts of flooding, especially in the worst-case scenario of the Nauels study (Nauels et al., 2017). Flooding these rivers would cause significant problems, possibly even resulting in relocation from these areas. The Charles, for example, would have an impact all the way to Waltham, Massachusetts, if not farther inland. Another impact impacting these regions is the altitude of many significant

buildings. In Boston alone, following the scenario where sea levels rise by 6.82 meters by 2300, Boston Logan Airport, TD Garden, New England Aquarium, Faneuil Hall, Massachusetts General Hospital, Tufts Medical Center, and the US Coast Guard Station in Boston would all be at risk (NOAA). As these are massive buildings that are impossible to move as a whole, the majority of these locations would likely be left behind. The regions around the Boston Harbor would be flooded beyond a livable standard, and the regions would likely be abandoned.

The sea level rising even to the best case scenario of 0.8 meters by 2300 would still cause flooding in over ten regions surrounding the Harbor, and that is before storms are taken into account. Currently, Boston will flood from storm surges due to large storms in the Harbor. If the sea level were 0.8 meters higher, then these effects would only be magnified.

The increased precipitation would also result in worse flooding for the Boston area. The USGCRP states that the winter is expected to have the highest precipitation increase, which would lead to large storm surges in the Harbor (Avery et al., 2018). On top of the rising sea level, these storm surges would result in massive damage in the Boston Harbor area.

Higher air temperatures could spell health risks due to high heat, such as respiratory and cardiovascular complications. The increased greenhouse gasses in the atmosphere also lead to dirtier air, further contributing to respiratory issues.

2.4 Climate Change and Toxic Chemical Safety

The best way to deal with toxic chemical safety depends mainly on the individual characteristics of each chemical. For example, "sodium peroxide and calcium carbide should be stored in airtight containers in a fashion that eliminates even the most remote possibility of contact with sources of water. Penetration of even small amounts of water may produce a violent reaction."(Dunkleberger et al., 1985). This can make chemical safety difficult for facilities, as standard forms of organization may not be effective in most situations. An example would be the alphabetical storage of chemicals by name. This is a bad idea, as "alphabetical storage has been responsible for cases where powdered magnesium was stored next to perchloric acid, sodium cyanide kept close to sulfuric acid, and phenol placed next to nitric acid on the shelf. An accidental spill involving the chemicals in these pairs could cause a major disaster" (Williams, 1983).

As storing by characteristics is the most effective, it is essential that facilities have the proper storage space. This can be a problem, however, as many facilities have a defined amount of space for their chemical storage. As stated by Gary Dunkelberg, “Considerations should be given to housing stored chemicals in multiple locations within the building to lessen the accident potential. Distinctly separate storage facilities are impossible; however, attempts must be made to maximize the physical distances between classes of chemical compounds within the storage area”(Dunkleberger et al., 1985).

There are some practices that can solve both of these problems at once, one of them being storing only non-reactive chemicals together (Williams, 1983). This is an effective chemical storage method, as having a dedicated section for non-reactive chemicals not only limits them to a specific location in the facility but also allows for more attention to be put on reactive chemicals. Another suggestion from Williams is to keep track of the facility's chemicals. This can be done by keeping a dated inventory of all chemicals that are stored in the facility. This not only allows for a record of all the present chemicals, but when these chemicals were stored (Williams, 1983).

2.4.1 Impacts on Facilities that Use Toxic Chemicals

As previously stated, the proper way to handle chemicals depends on the individual characteristics of each chemical. To handle these chemicals in the best way possible, it is crucial to determine their vulnerabilities. This includes proper storage and determining prevention methods for emergency situations. “The vulnerability is defined as follows: when the tank area is subject to the disturbance of various hazard factors (natural disasters, human error, terrorist attacks, etc.), the tank has an inherent property which may cause the escalation of accidents due to the material hazards; the distribution of tanks; the lack of emergency response, etc.” (Hua et al., 2019). The way chemicals should be stored depends on each possesses vulnerabilities, but the effects of climate change should be considered.

According to the United States Government Accountability Office (GAO), over 11,000 facilities, of which a subset of them are Toxics Use Reduction Act (TURA) filers, in industries such as energy, chemical manufacturing, and water and waste management that are covered under the federal Clean Air Act that “make, use, or store extremely hazardous chemicals in amounts that could harm people, the environment, or property if accidentally released” (Booker

et al., 2022). Of these facilities, over 3,200 of them are located in areas where natural hazards, such as wildfire, storm surge, sea level rise, and flooding, take place (Booker et al., 2022). This is important as all of these events could have severe ramifications on the storage of chemicals.

An example would be a facility in a region that is likely to flood often. As stated by the GAO, “flooding may inundate tanks and pipelines, leading to corrosion, severance of pipe connections, and rupture, according to FEMA” (Booker et al., 2022). The workers at a facility susceptible to a flood should be prepared for a flood to come at all times. This would require that any chemicals be stored in a way and location so that it does not react with the flood water. If a facility needs constant power to keep a particular chemical cool and the power goes out, these facilities should have backup generators prepared so that an accident does not occur. As stated by the GAO, “accidental chemical releases at these facilities can result in fatalities and serious injuries, evacuations, and other harm to humans, according to the Environmental Protection Agency (EPA)” (Booker et al., 2022). With these potential accidents in mind, facilities that use hazardous chemicals from the Toxic or Hazardous Substances List (301 CMR 41) have an obligation to protect the workers in the facility and the community surrounding the facility.

3. Methods

Our project goal was to help The Massachusetts Office of Technical Assistance and Technology (OTA) update their chemical safety training materials by assessing the needs of current Toxic Use Reduction Act (TURA) filers. In order to accomplish this goal, we developed three objectives. First, we evaluated how TURA filers are preparing for climate change. Next, we sought information from OTA stakeholders on stakeholder companies' needs. Finally, we analyzed the survey and interview data and used these findings to develop recommendations for OTA on additional training or technical assistance needs of TURA filers and stakeholders.

Objective 1: Evaluate how Toxics Use Reduction Act (TURA) filers are preparing for climate change throughout Massachusetts

In order to gather data from Toxics Use Reduction Act (TURA) filing companies, we had to make a decision on the best way to gather our desired data. As there are a little more than 400 TURA-filing companies in Massachusetts, individual interviews with all companies would have been impossible given our limited time. Case studies would not have been relevant either, as we were looking for current data from several companies. This led us in the direction of a survey, which was the path we decided to go down. Before we conducted our survey, we had to identify the ideal survey recipients. As OTA provides assistance to TURA-filing companies, we believed that surveying TURA-filing companies would give us the best feedback about climate change and chemical safety. After identifying the survey recipients, we began writing survey questions that were sent to 397 TURA-filing companies.

The project team worked with OTA to develop survey questions on climate change and facility preparedness. We had a weekly meeting with OTA to review the questions. In these meetings were individuals from OTA, such as Technical Assistance Providers, who work directly with companies, and Policy and Outreach staff. Between all of the real-world experience working for and with companies, the staff at OTA made these meetings extremely beneficial. Having the knowledge of OTA also helped us forge questions that we would not have even thought of. By working closely with OTA, we refined our questions in a week and a half through four meetings. The survey consisted of 25 questions and was expected to take between 15 and 30 minutes to complete. The questions in this survey focused on relating directly to the TURA-filing companies. These questions were about emergency preparedness in the facility,

communication with local and regional agencies that are beneficial, submission of federal requirements, and overall preparedness for climate change events. Once we were happy with the questions, they were sent to the WPI IRB system for approval. Our next step was to look at the flow and cohesion of our survey.

When assessing the flow of the survey, we had to consider timing. Since we wanted to get as many completed surveys as possible, we had to make sure the survey was not longer than we thought was reasonable. We aimed for fifteen to thirty minutes to complete the survey, and we met this mark by removing a few questions from the survey. We felt that by removing these questions, although losing some potential data, we would get better overall data and receive more responses from a shorter survey. We also did not worry too much about these missed questions, as OTA reminded us that we could recycle these questions for our interviews. Once we were content with the status of our survey, we had to deliver the survey (Appendix 1) to 397 TURA-filing companies.

We used Qualtrics (Copyright © (2022) Qualtrics. Qualtrics and all other Qualtrics product or service names are registered trademarks or trademarks of Qualtrics, Provo, UT, USA. https://www.qualtrics.com) as the basis for our survey because of their streamlined user experience, exportation of data, and ease of data compiling. First, OTA staff provided a Microsoft Excel file that consisted of 400 unique, fake email addresses that we could use to "send" the survey to. In reality, we used these fake emails to generate unique links to the survey. As the TURA-filing companies are confidential, we could not upload their real email addresses to Qualtrics. Because of this, we associated the unique links for the fake emails to real emails from TURA filers. This way, we could keep the TURA-filing companies' identities hidden, while still being able to know who submitted what data in the survey.

After we had unique links for the survey, we made sure that all of the content of the survey was correct in Qualtrics. This consisted of making sure recode values were consistent across all questions, skip and carry-forward logic were correct and as intended, and the grammar in the questions themselves was correct. Once reviewed with OTA, we then created a mail merge email through Microsoft Word (Microsoft, 2022). This allowed us to use one email outline, while changing information such as the name of the recipient, but more importantly the survey link. With the mail merge complete, we sent our survey to 397 TURA-filing companies with 397 unique links. This survey in its entirety can be found in Appendix 1.

Objective 2: Seek out information from OTA stakeholder companies for a deeper understanding of consumer needs

As surveys can only be so long and contain so many questions, we wanted to gather information that showed what specific needs were present in OTA stakeholders' companies. To do this, we worked with OTA to conduct 4 interviews with specific stakeholders about climate change preparedness. These interviews were held with representatives of agencies and organizations that OTA has collaborated with in the past. These agencies and organizations were The New England Consortium, Massachusetts Emergency Management Agency (MEMA), the Office of Environmental Stewardship for the City of New Bedford, Massachusetts, Chubb Global Risk Advisors, and more. The different experiences from these groups allowed us to get a wide range of relevant information for OTA.

Similarly to the survey question process, we ran our questions by OTA staff members to make sure the question were understandable and relevant. Thankfully, they once again provided great feedback and recommendations. Their understanding of the individuals and their careers helped us tailor the interview questions to each individual. After a shorter review window, we sent our questions to the WPI IRB system to get approval for our interviews. Once the IRB approved our questions, we started to conduct interviews with stakeholders.

We also got an opportunity to speak with 4 stakeholders who gave insight into how they felt about their collaborations with OTA. These stakeholders are not working directly with companies, but are partners that have worked with OTA in the past. Thankfully, these stakeholders came from different areas of expertise and focus. The first stakeholder that we got to speak with was Michele Paul, the director for resiliency within the city of New Bedford. Her role allows her to oversee many energy initiatives taking place in the city, and put new programs in place to keep the largest port in New England environmentally friendly. Our second stakeholder was John Viveiros. John works as a Technological Hazardous Unit Supervisor at the State Emergency Response Commission (SERC) of Massachusetts. Our third interviewee was Tom Estabrook, who works as a Project Director at The New England Consortium (TNEC). Tom has been a project director at TNEC for four years now, and described TNEC as federally funded worker health and safety training. Our last interviewee was Todd Dresser, who is working at Chubb Global Risk Advisors, and has been a previous presenter at OTA's Chemical Safety and

Climate Change Resiliency trainings for Local/Regional Emergency Planning Committees and local emergency managers. He is also a Certified Massachusetts Toxics Use Reduction Planner (TURP), Certified Hazardous Materials Manager (CHMM), and Environmental Health and Safety (EHS) compliance manager and consultant.

These interviews were conducted over Microsoft Teams. This was mainly done for flexibility reasons, and the geographical location of OTA offices compared to stakeholders' locations. Interviews typically lasted between thirty minutes and one hour, depending on the number of questions asked, how many follow up questions we asked in the interview, length of stakeholders' responses, and general time constraints. In all, we conducted 4 interviews with OTA stakeholders as most of the others we were planning to interview were busy or had other matters to attend to. The questions we asked stakeholders can be found in Appendix 2.

Objective 3: Analyze data and develop recommendations on how to meet the existing chemical safety and climate change preparedness needs of TURA filers/toxic users

The main deliverable of this project was to provide the OTA with the survey results and interview information so that the OTA could improve their practices. We analyzed our data by exporting our items from Qualtrics (Qualtrics, 2022) into Excel (Microsoft, 2022). We did this so that we could get a raw form of the data, which showed more details than the formatted data on Qualtrics. Some of these details included which specific companies answered which specific questions, which choices companies selected on questions where they could choose more than one option, which companies requested aid from OTA, and which companies did not complete the entire survey. Along with this, the exported raw data showed which companies agreed to the confidentiality agreement at the beginning of the survey, and which companies did not. The exported data also allowed us to configure the data in any way we chose, as opposed to the limited options on Qualtrics. The raw data will also stay with OTA, in case they need to reference it in the future.

3.1 Limitations

As of the time of the sending of the survey, we had initially sent it out to 397 companies. However, due to out-of-date information on company emails, there were about 32 bounce-backs,

meaning only about 365 companies actually received the email. Most of the data will remain non-descript, as we must keep the data on specific companies as confidential as possible. At the end of our research, we received 39 complete survey responses. These low response rates could be due to the fact that companies may be cautious about sharing information with a government agency, for fear of being found non-compliant. Another option could be that companies are not aware of the non-regulatory standards of OTA. Another possibility is that they, as busy companies, could not find time to answer the survey. Also, the emailed survey could have ended up as spam/trash mail for them. Finally, the fact that the survey was voluntary might mean it was not on their priority list. We have no way of knowing if the companies who did not respond would have provided us with data that correlates to the data we collected. There were also other limitations as the team was originally planning to interview eight stakeholders, yet due to time constraints and busy schedules, we were unable to get responses from all of them. For our interviewee Todd Dresser, unfortunately, we were unable to interview him directly. Thankfully, he was willing to answer some of our questions through email.

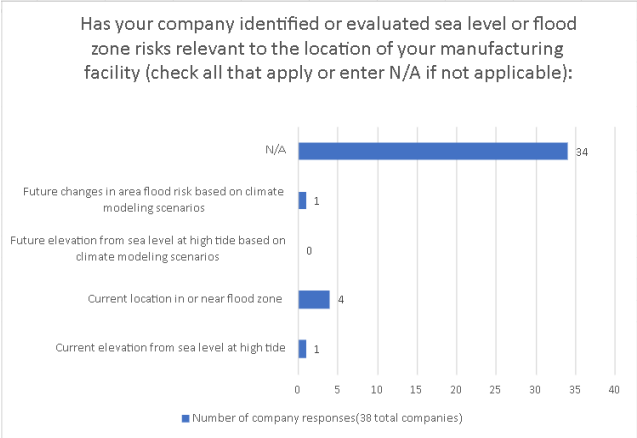
4: Findings & Data

Throughout our project, the team was able to gather data from multiple valuable sources that allowed us to present OTA with results that were what we were looking for. We got multiple answers from the surveys allowing us to get multiple findings that were clear pointers of areas where OTA could improve the services they provide TURA filers as the results pointed at areas where companies need the most assistance as well as general overviews that could help OTA. Based on the data collected from our surveys and interviews, we have 6 findings. Our first finding was that many facilities are not meeting federal requirements because these laws are not effectively enforced. Facilities do not take climate preparedness into consideration. Our third finding was that back-up power, such as those provided by emergency generators is not accounted for by many facilities. Our fourth finding was that, outside of emergency responders, facilities are not in good contact with their communities. Our fifth finding was that Most facilities lack sufficient emergency preparedness plans for their employees. Our sixth and final finding is that, while they can still improve, OTAs services are helpful and connections between facilities and agencies help as well.

4.1 Facilities do not take climate preparedness into consideration

The team has discovered that a lot of these companies have a somewhat alarming lack of climate change preparedness.

Figure 5: Flooding risk assessment from companies



A couple ways facilities show lack of awareness is with their geographical location, and analysis of climate change predictions. To find this information, we asked companies, “Has your company identified or evaluated sea level or flood zone risks relevant to the location of your manufacturing facility.” 39 companies answered this question, and 34 of those facilities answered “N/A” to the question. Of the companies that did know their current location, five companies were worried about their current location, one company was concerned with their current elevation, and one company was concerned with their location based on future flood models. This data is also shown in Figure 6. Although companies selecting “N/A” may not be aware of their current or future situation in regard to climate change, these companies could also not have any risks at all present. This mistake was an oversight on our part, and any future surveys should separate these possibilities as different choices. That being said, the vast majority of companies answering “N/A” was not expected, and could show that companies are unaware of their geographical location in regard to current or future climate predictions or believe that their geographical location is not vulnerable to such impacts from climate change. This is an area that OTA should look into comparing the information about the location of the facilities to the companies’ responses.

Thomas Estabrook mentioned in our interview that climate change has been discussed increasingly over the years, but during the trainings they often do not explain how dire the situation is and how fast it will keep changing. He also said that some people do not go into deep detail regarding climate change, as it can be perceived as a scary topic.

Todd Dresser believes that climate change should be incorporated into all applicable corporate policy simply for business continuity and financial health and should be considered when evaluating chemical storage and handling, potential site impacts, accessibility of suppliers, responders, and/or contractors to your site, durability of utilities needed to maintain operation, and secondary events that could result if your site was impacted or flooded. He mentioned that most businesses do not assess factors like the costs associated with these impacts, how quickly the facility can recover from the events, or the likelihood and potential severity of an event. Todd thinks they should do so for the safety of not only the community, but also for the safety of their business. This ties up to something Thomas mentioned in our interview, where he also stated that

he is personally concerned about the ways climate change will impact the workplace and how the economy needs to change in order to better deal with this.

This lack of action is a major concern. If companies do not act fast, then climate change could cause potentially dangerous accidents, as flooding in these facilities could lead to damaged equipment and loss of material. This, in the context of facilities who have to manage chemicals from the toxics or hazardous substances list, could cause leaks and other dangers to the surrounding communities.. Even if companies believe that it is non-applicable since they are not near a coast, companies might still be near a river or lake nearby. With the increase of precipitation and the higher risk of storms, discarding flooding preparations is rash.

Unfortunately, we were only able to ask one question regarding climate change during our surveys. It would have been good to ask other questions that did not regard flooding like: how are companies preparing for climate change issues? What are companies' plans to deal with fast alternating temperatures? We omitted these questions because written responses would have taken substantially more time for the companies to answer, and we wanted the survey to have the greatest amounts of responses without taking up too much of their time. But, to OTA & us, one statistic from our survey in particular was especially concerning regarding climate change preparedness: lack of emergency power sources.

4.2 Continuous Power Processes, Back-up Power & Emergency Generators are not accounted for by many facilities

Figure 6: Continuous power requirements for processes of companies

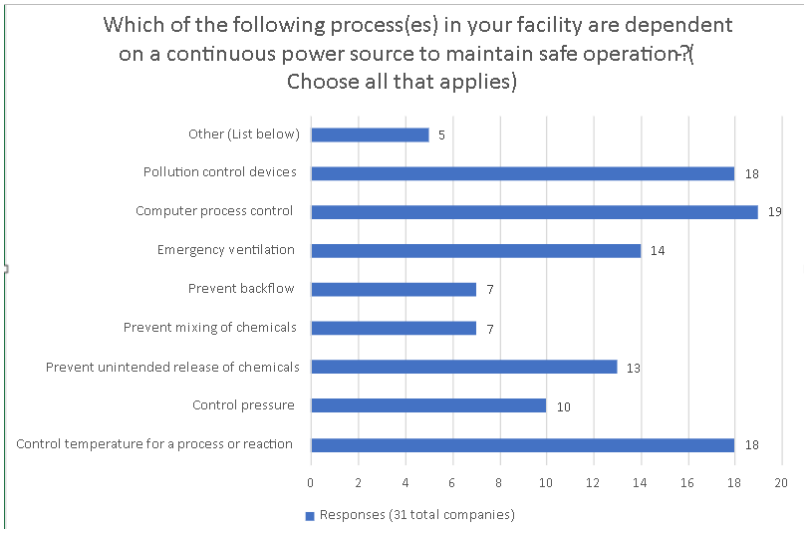


Figure 7: Back-up power availability for processes of companies

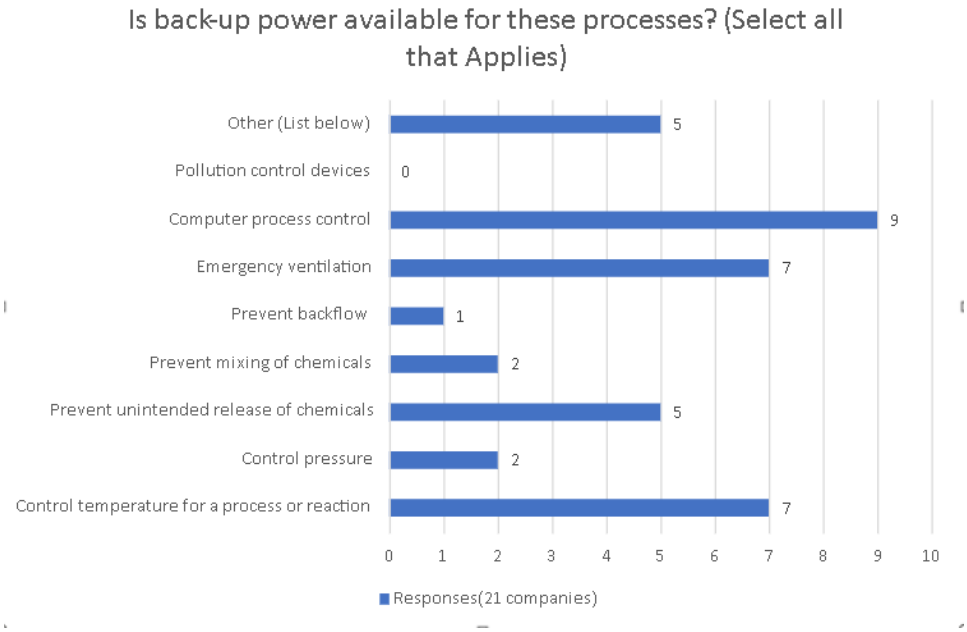


Figure 8: Graph of emergency generator availability

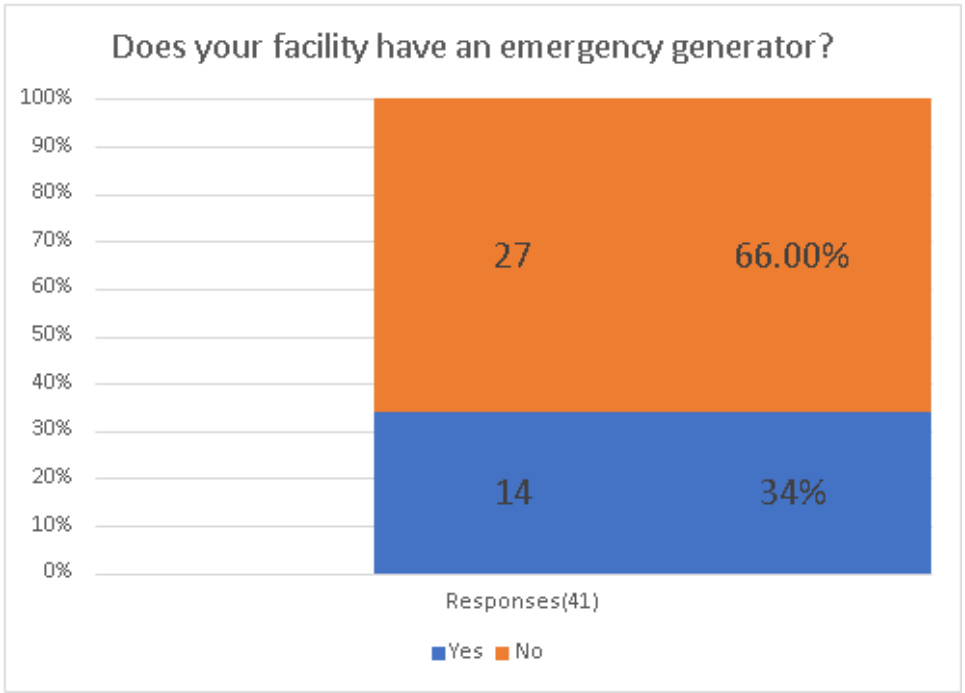


Figure 9: Number of companies' emergency generators

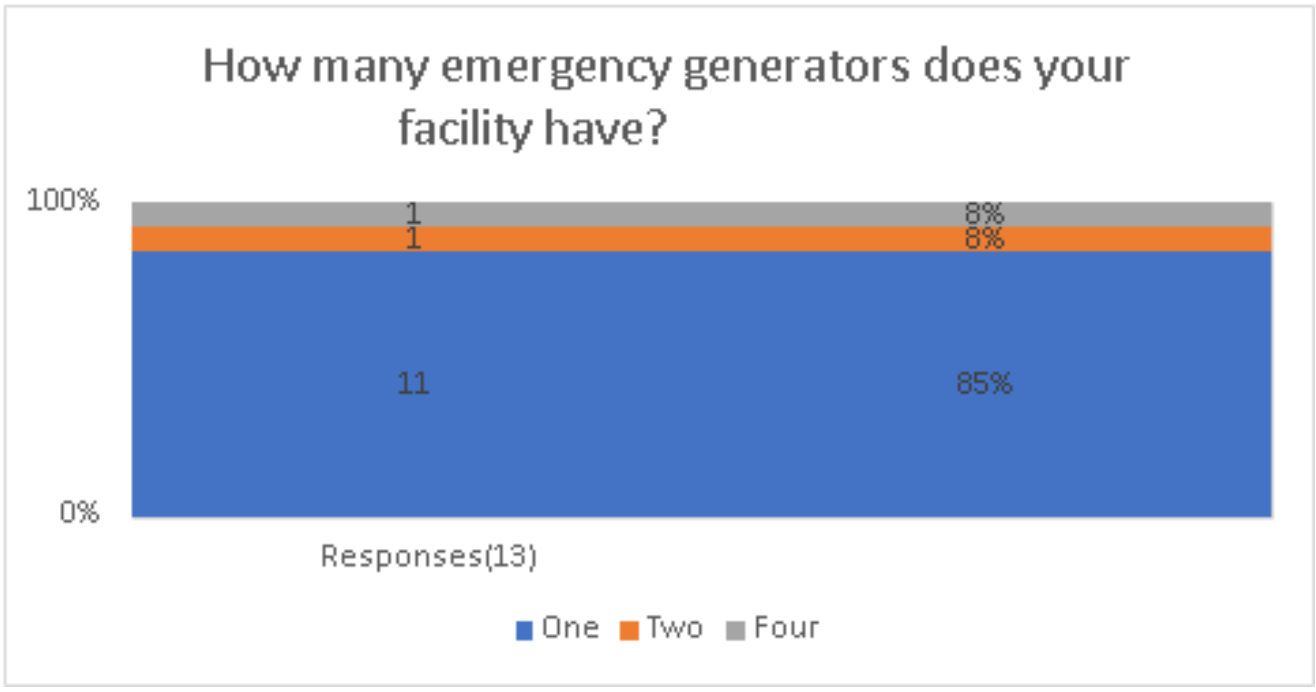


Figure 10: Type of fuel of emergency generators of the companies

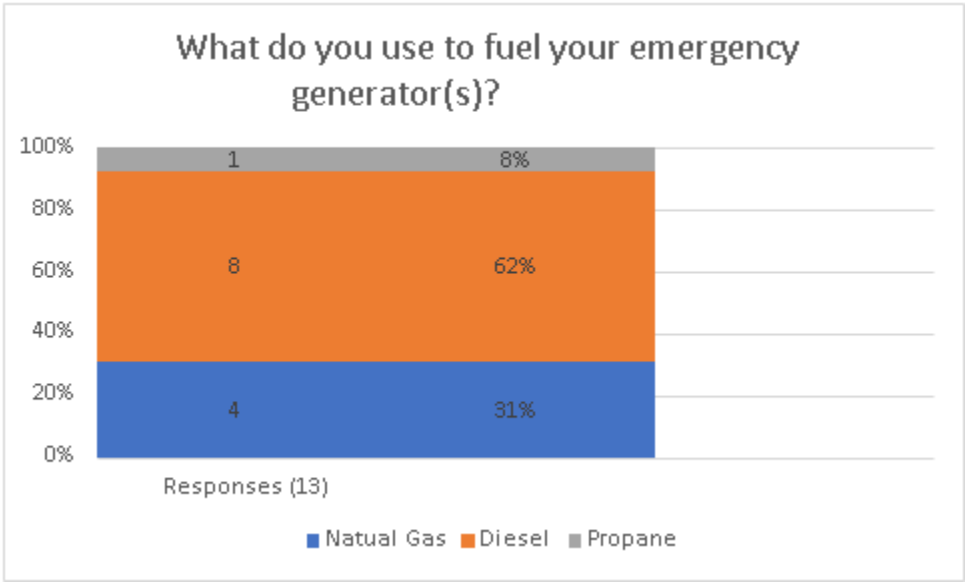


Figure 11: Duration of supply of power during extended power outage

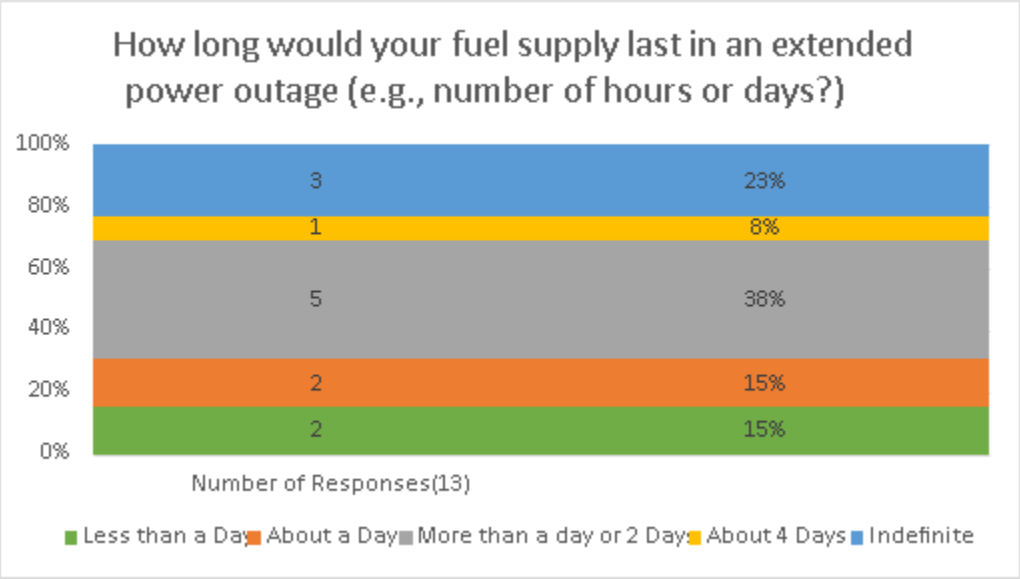


Figure 12: Knowledge of location of emergency generators

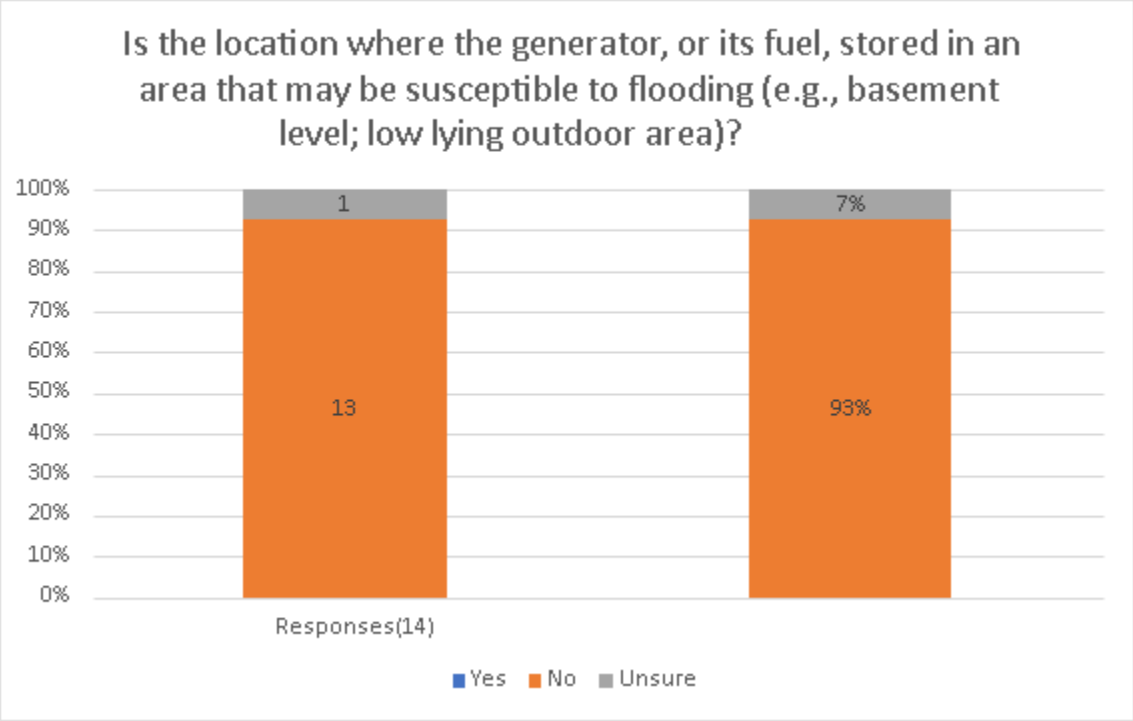
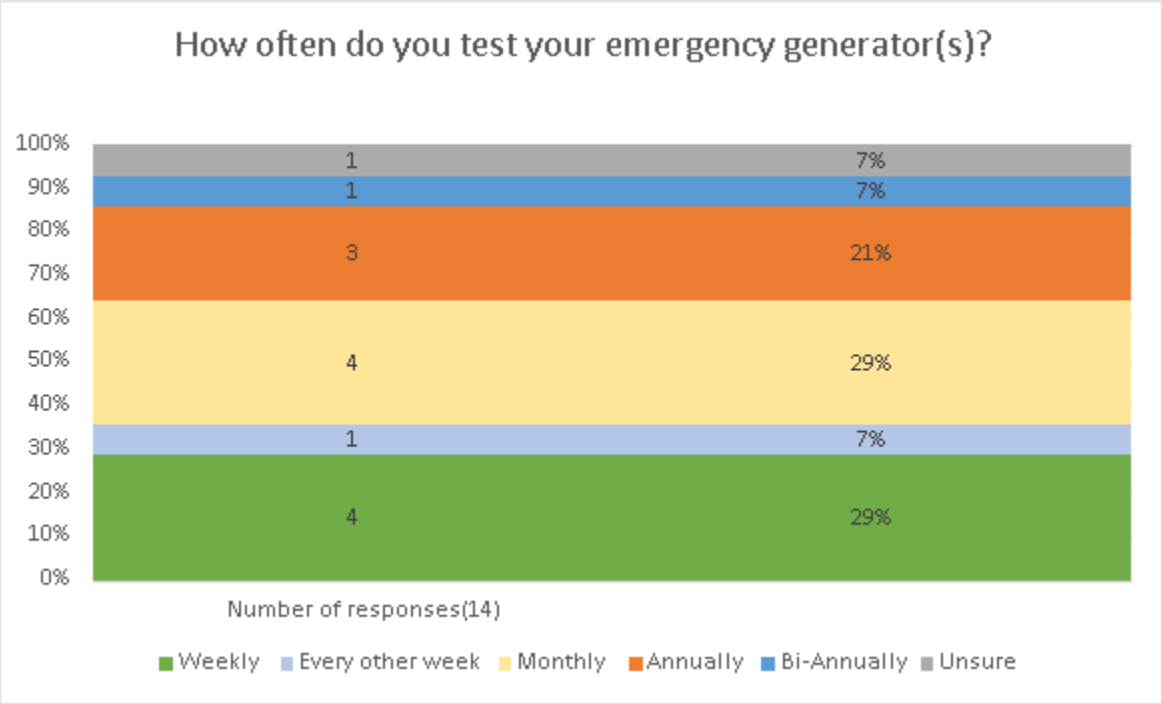


Figure 13: Frequency of testing of emergency generators



Following up the last finding, out of 41 responses, only 14 companies said they had at least one emergency generator, with the other 27 companies saying they did not have one. Of the 14 companies that have emergency generators, 11 of them have one generator, one has two generators, one has four generators, and one was unspecified. This comes as a surprise, since it was expected that these companies keep a certain amount of essential preparations, yet unlike what was initially expected by OTA as well as us, this seems to not be the case. Our results show that 9 of these 14 generators run on diesel, which has an average reserve of 24-48 hours of run time on average. We also received one answer stating their generator ran on propane, and that they expected the generator to have 48 hours of fuel on standby. The other common answer received was natural gas, which received four answers. As natural gas is typically piped in a way that provides constant flow, these generators can run for much longer than diesel. Another important detail to note is that the companies that do have a generator have the generator, or its fuel, stored in an area that is not susceptible to flooding, as seen in Figure 13. As for companies that stated they did not have an emergency generator, in the case of a long-lasting emergency, these companies might not be able to provide energy to certain essential processes. The main reason for this data to be concerning is that, as can be evidenced by Figure 7, most of these

companies have certain amounts of these processes that require a continuous power in order to function safely.

When asking about continuous power dependency, we asked OTA staff to provide us with typical processes that require such power dependency. In all, we gave companies nine options, and they were allowed to select multiple. The options in their entirety are shown in Figure 7. Most important for accident prevention are; Control temperature for a process or reaction, Prevent unintended release of chemicals, Pollution Control Devices, and Computer Process control. Of the 31 companies that answered this question, and across all nine options, there were 111 processes that were accounted for in the survey that required constant power to maintain safe operation. The distribution of these processes can also be seen in Figure 7.

After this question, we used carry-forward logic in Qualtrics (which allows selected choices from a previous question to be carried forward to the next) to ask if companies had back-up power available for their selected choices. According to our data, of the 111 processes that need continuous power, only 38 of them have back-up power available. As an example, 19 companies stated that their computer process control required continuous power, yet only 9 companies said they have back-up power available for their computer process control system (as can be seen in Figure 8).

This statistic is concerning, as an increase in the severity of storms due to climate change could lead to more power outages that these companies need to prepare for. If these companies are not prepared for extended time without power, systems like unintended spill prevention could shut off, resulting in large spills during power outages. These companies do not possess back up power available for these processes, either because they do not possess a backup power supply or they are only prepared for a safe shutdown in the case of an emergency. This is of pressing concern, especially for those who are most vulnerable to these kinds of accidents: the workers in the facilities and the communities surrounding them.

4.3 Facilities are not in good contact with their communities outside of emergency responders.

Figure 14: Stakeholders in conversation with the companies

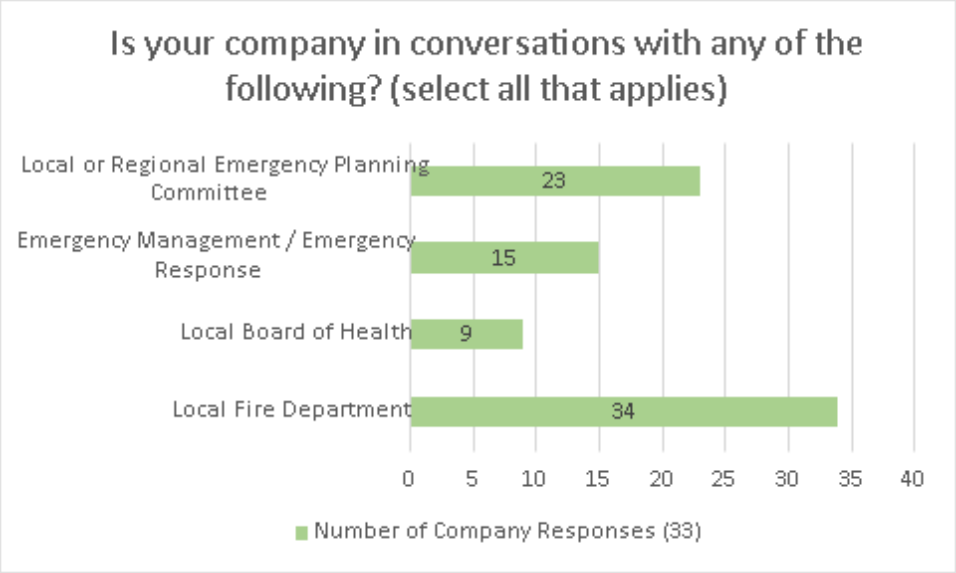


Figure 15: Companies that want to be connected by OTA to stakeholders

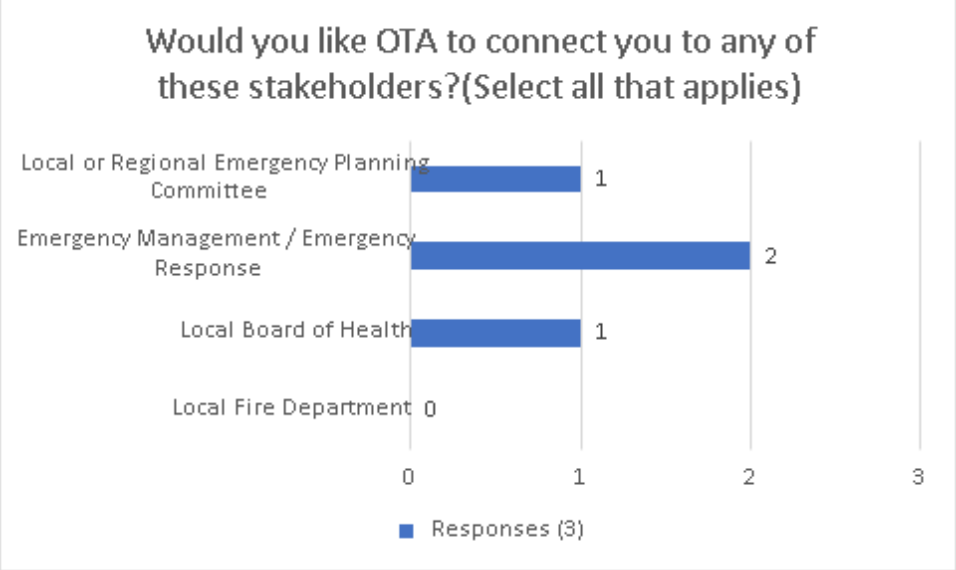


Figure 16: Emergency responders that are aware of chemicals present in facility

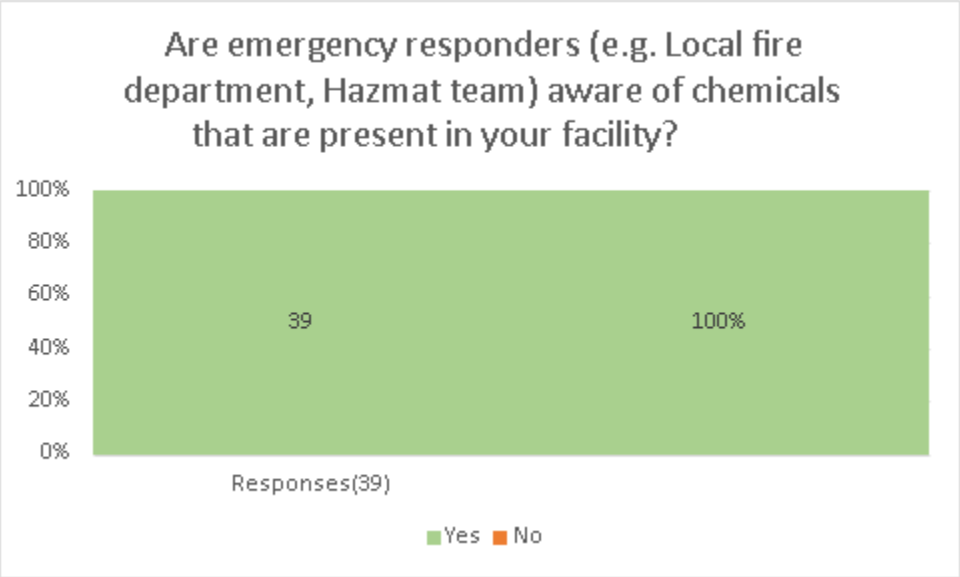
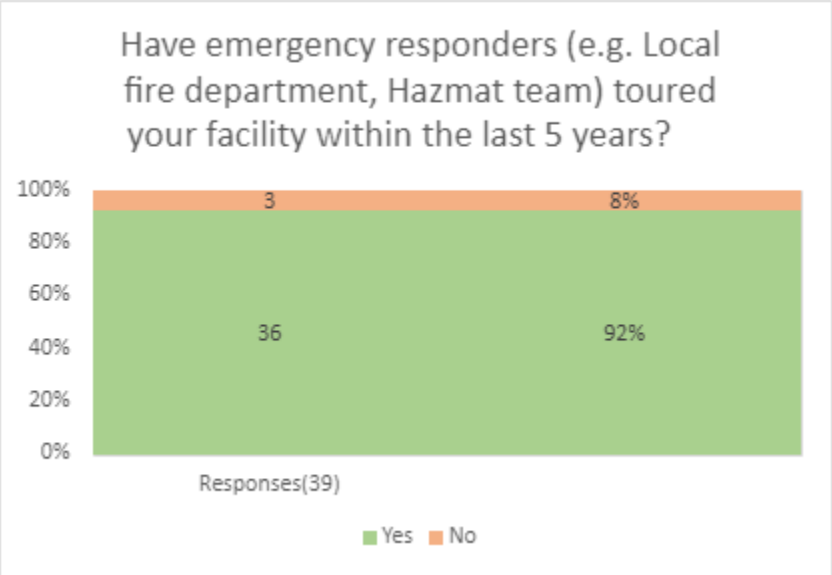


Figure 17: Emergency responders that have toured facilities recently

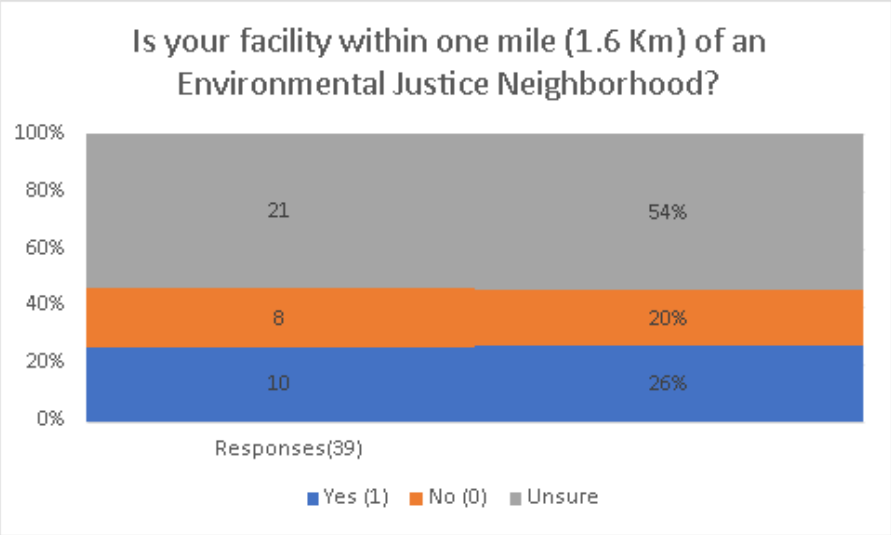


One of OTA's missions is to connect companies to local stakeholders, such as local fire departments, boards of health, emergency planning committee, and emergency

management/emergency response. This is in order to make sure facilities and the surrounding areas are safe, prepared ahead of time, and are capable of assisting with any emergency. Because of this, we asked companies if they were in conversations with any of the following; Local Fire Department, Emergency Management / Emergency Response, Local or Regional Emergency Planning Committee, and Local Board of Health. The results showed that 34 of 39 companies are in contact with their Local Fire Department, which is the most important group to be associated with. 23 of the 39 companies are in communication with their local or regional emergency planning committee. We also provided the option to companies for OTA to connect them with any desired stakeholders, so OTA can continue to make companies and their communities safer. This can be seen in Figure 21, where it can be seen that a few of companies would like to connect with stakeholders they are not already in contact with. OTA knows who these companies are and will help them contact the stakeholders. Another aspect that companies are doing well is involving and informing emergency responders about what is going on in their facility. As seen in Figure 22, 39 of 39 companies that responded to that question are in communication with the emergency responders, and the emergency responders are aware of the chemicals present in the facility. Additionally, in Figure 23, 36 of 39 of these companies have had their emergency responders tour their facility in the last 5 years.

These findings are good news for OTA since it means that facilities are at least aware of whom to get in touch with in case of an emergency, and that emergency responders have relationships with these facilities. Certainly, these connections will be useful for the facilities. Yet these impressive and helpful actions do not justify the lack of awareness of the communities around the facility, because even if a disaster can be contained, the communities around the facilities would not be aware of such risks until it is too late.

Figure 18: Awareness of facilities of Environmental Justice Communities within one mile of company facility



One of the results of concern was related to geography is that of Environmental Justice Communities and how companies lack awareness of such communities.

In the survey companies were asked, "Is your facility within one mile (1.6 Kilometers) of an Environmental Justice Neighborhood?" 39 companies answered this question, with a resounding 21 answering "Unsure." Along with that, 10 companies answered "Yes," and 8 companies answered "No." A graph of this data can be found at Figure 19. This data shows that awareness of Environmental Justice Communities is not at the forefront of the Toxics Use Reduction Act (TURA) filing companies that filled out this survey, and highlights a clear area of improvement that the OTA can make in their training. With that being said, there are areas where OTA training is shown to be effective

Our interviewee, Todd Dresser, believes that communication and interaction between industry and the local community is critical, as both parties are interdependent. "From an emergency planning/response standpoint, the community expects businesses to manage/utilize hazardous materials in a safe manner. Businesses expect local responders will be prepared to provide immediate and effective emergency response in the event of a problem." He worries about this, as even though this relationship is to be expected and is required under a variety of

regulations, neither side really pushes this issue until a problem occurs and the problem/impact has already occurred. “Improved awareness and education on both sides to better understand their interdependence and the need for pre-planning and coordination would help both sides better identify, plan for, potentially mitigate potential hazards while also allowing both parties to better prepare for potential problems.” He mentions that the challenge is that businesses view community interest as an intrusion, and communities lack the knowledge and interest to review chemical hazards and to help promote hazard mitigation. Many businesses view regulation as conflicting with business’ goals, simply due to the need to complete additional duties. The requirement to make site modifications are often viewed simply as added costs.

4.4 Most facilities lack sufficient emergency preparedness plans for their employees

Figure 19: Type of emergency preparation plan that companies practice

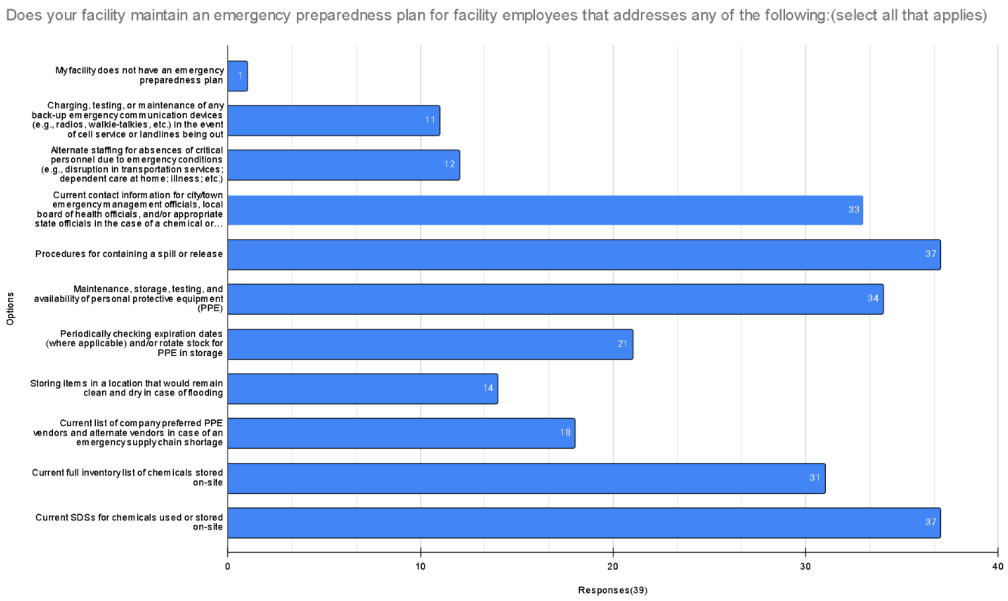


Figure 20: Frequency for practicing emergency preparedness exercises for employees

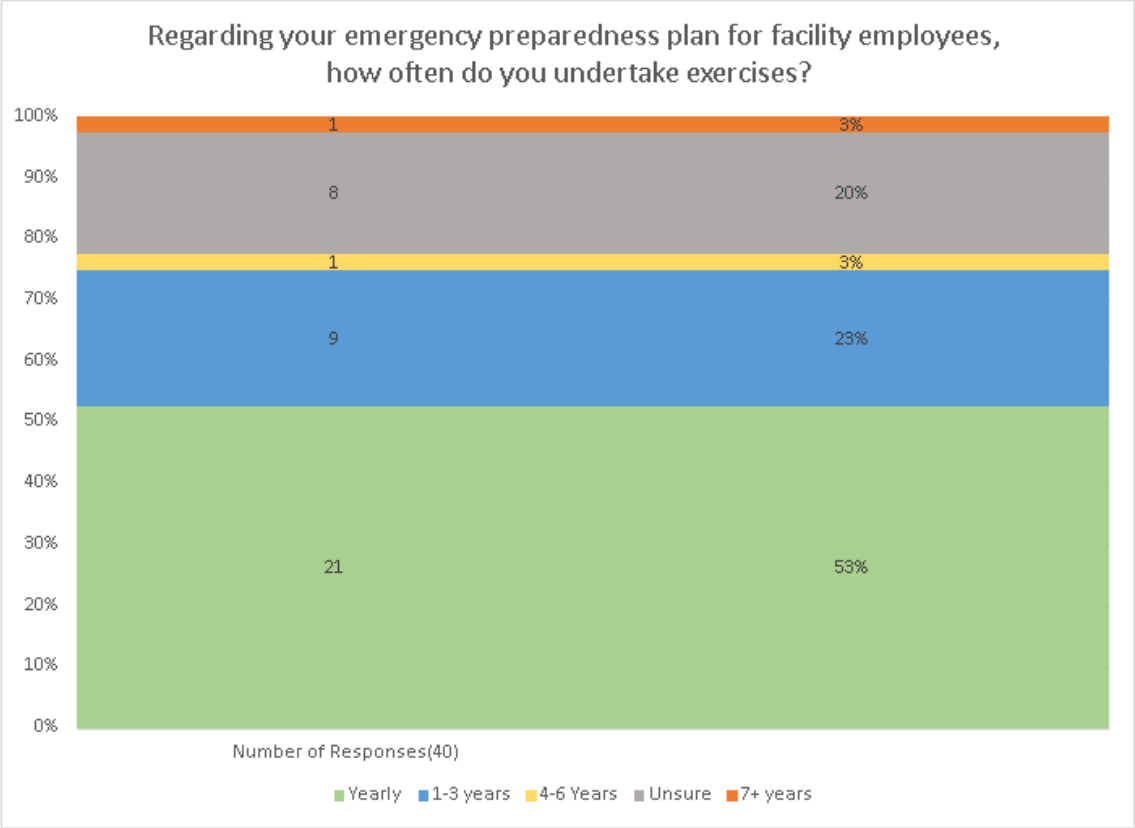


Figure 21: Frequency of updating emergency preparedness exercises for employees

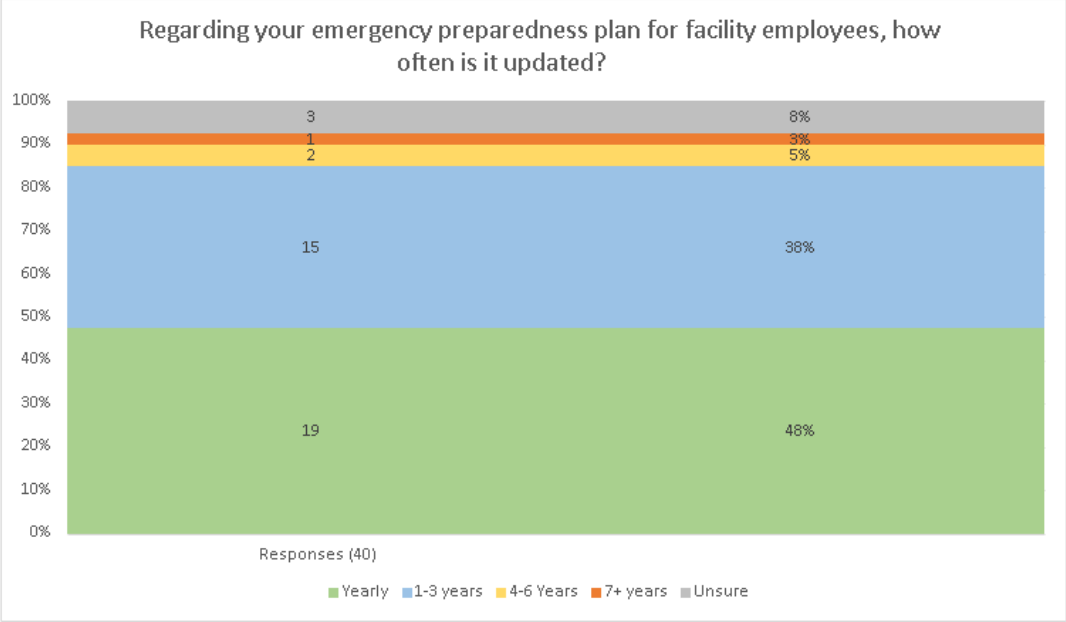
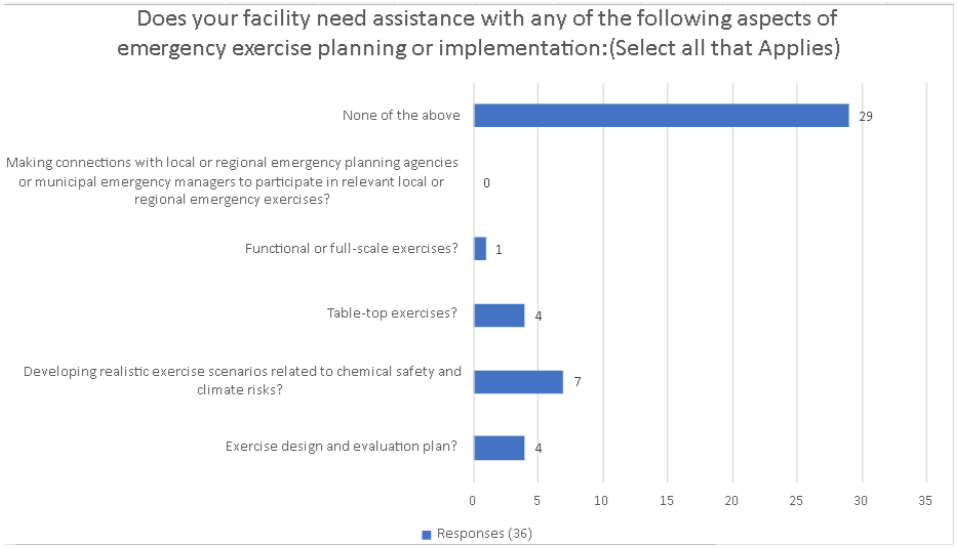


Figure 22: Facilities looking for assistance for emergency preparedness exercises



Emergency preparedness plans are another area where facilities are having trouble. During the question shown in Figure 15, we asked the companies which types of exercise they are doing for their emergency preparedness, and the responses were mostly positive. All the companies that filled out this survey, with the exception of one, had at least one form of training available for their employees. These are great first steps toward effective emergency preparedness plans, yet when we asked companies, "Regarding your emergency preparedness plan for facility employees, how often do you undertake exercises? (Figure 16)", our results were less positive. Of the 40 responses received, 21 companies said they practice exercises yearly. This shows that at least half companies are aware that emergency preparedness plans are important and that companies are actively practicing their plans in case of an emergency. The reason this is worrying is that when these exercises are being practiced between time periods larger than a year, it is increasing the risk of injury or accidents for the employees as there could be changes over the years and some employees might not be able to be prepared for them. For example, if a new employee joins the company during a timeframe where the pieces of training are not being given, they might not be aware or informed on what to do in case of emergency. This ties into the next question asked, shown in figure 17 where we asked companies how often these trainings are updated. The responses show that barely half of them update their pieces of

training once a year, which is worrisome. The reason for this worry is that some companies might have outdated pieces of training. As mentioned before, there are multiple changes that could happen that could affect the pieces of training and what the company needs at the moment. The data collected from these two questions show that a considerable amount of companies do not properly prepare their employees in cases of emergency and some of them could be undertrained and/or under informed on what to do in case of emergency.

Another important detail on emergency preparedness is the question that followed, shown in Figure 18, where we asked companies if they would like assistance with some aspects of emergency exercises. Even though most companies answered that they do not want any assistance, some of the companies wanted aid. This result shows that the companies that want assistance with the exercises are willing to improve, or they are knowledgeable of OTA and the work they do and recognize that their assistance is helpful. As for the companies that do not need help, it could be possible that they are confident with the exercises that they already have in place and do not need to change. It is important to know that OTA does not charge for their services, so hopefully, the companies were aware of this when answering this question.

Todd Dresser believes that it should be incorporated into all applicable corporate policy simply for business continuity and financial health. The key challenge is that most facilities look at emergency planning from the point of view of, ‘what should we do in the event of a release,’ rather than looking at it first in terms of ‘how we prevent a release.’ They should consider the ways they can take action to lower the risk of release, plan out and review which factors had changed from the time the original plan was made, and the potential financial impacts related to a spill or business disruption, as money is the key motivator for most facilities.

4.5 OTAs services are helpful, and connections between facilities and agencies help as well.

Our interviewee, Todd Dresser, expressed some thoughts about the Toxics Use Reduction Act (TURA), as he works closely with a variety of regulations and has experience with TURA. Based on his experience, TURA is less than an afterthought with Massachusetts facilities, and MassDEP rarely inquires about TURA planning/reporting when inspecting local facilities. The reason for this is that many of the federal standards incorporate industry consensus standards and federal guidelines that already require regulated facilities to consider

and address climate change and resiliency as part of their routine chemical storage and management. These standards offer potential partners leverage to promote change at industrial facilities. By taking the time to explain the 'why' behind a regulatory requirement, or the suggestion to strengthen/modify a facility due to climate change, you can more effectively motivate facilities to make the change. If they understand the rationale and how basic changes can lessen a risk and support business continuity, then there is greater likelihood the facility will consider and make a change. Agencies rarely take the time to explain the 'why'. Most facilities have not identified all the cost variables they should when conducting hazard analysis & mitigation, and emergency planning. More businesses could use help identifying and understanding these factors. A better understanding of financial risk would help to motivate more facilities to take action.

With our interviews, we found that those that personally attended any OTA trainings, and had personal connections with staff on OTA, have found their recommendations and advice helpful to their communities and their services beneficial. When speaking with Michele Paul, she told of many positive interactions with OTA; She first became aware of OTA through a presentation held by Tiffany in 2007, and was impressed with what services they had available. Whether on trainings pertaining to strictly New Bedford, or on various workshops that can improve the livelihoods of other communities around Massachusetts. Mrs. Paul believed her connection with OTA had a positive impact on her work and the New Bedford community as a whole.

Another interviewee who also had this view was Thomas Estabrook. One sentiment shared by OTA and Tom is that the core mission of training is effective adult education. Because of this, TNEC has trainings in person for towns, cities, and even tribal organizations. Along with these groups, TNEC has worked closely with OTA for the last five years. Specifically, Tom worked with OTA to provide a presentation on Chemical Safety & Climate. This is important, as Tom mentioned that climate trainings are being increasingly discussed at TNEC.

The interviewee, Todd Dresser, recommended OTA should seek to incorporate and develop a collaborative approach that builds upon the other regulatory requirements that have emergency planning and chemical management requirements included within those standards.

Hopefully, the companies that answered this survey will become more aware of OTA and the work they do. The hope is that companies can forge a long lasting relationship with OTA in the future. Specifically, there were 2 companies (answering question 16 of the survey) that wanted a follow up on the survey with OTA, and OTA will be in contact with them with everything they might need help with. It is important to note that we are unable to mention the companies' names in this report due to confidentiality. Another point that for the survey, only one member representing the company answered.

We are very grateful towards all of the individuals that took time off their busy schedules to answer our questions and come to our interviews. Their input was invaluable to our project and helping OTA get a firsthand view on how they can improve their services. We hope that OTA keeps in touch with all their stakeholders to gain more feedback in the future.

Chapter 5. Recommendations / Conclusion

Based on the findings reported in Chapter 4 and in Appendix 1, we have three main recommendations for OTA.

5.1 Recommendation 1: *We recommend OTA develop additional training related to the dangers present regarding processes that need constant power, and back-up power for these processes*.

As our findings show, several companies have processes that require constant power in order to function safely. Our findings also show that several companies do not have emergency power for these processes, or emergency generators at all. Processes such as prevention of unintended releases of chemicals and pollution control devices could cause disaster if not properly powered. Specifically, we recommend OTA expand trainings about emergency generators, to make it clear that back-up power is an essential component of climate change preparedness. These trainings could be based around an example accident or company, that shows the dangers of not having back-up power. An unintended release of hazardous chemicals from the Toxic or Hazardous Substances List (301 CMR 41) could harm factory workers, members of the surrounding community, and local wildlife. Extreme climate events such as hurricanes and thunderstorms could lead to an increase in power outages in the near future, which would put these communities at even higher risk.

5.2 Recommendation 2: *Increase the awareness of nearby communities and risks of facilities*.

Our data shows that several companies are unaware if their facilities are near an Environmental Justice Community (EJC) or not, which could pose greater risks to these EJC's. As these communities are already underserved, a hazardous chemical incident or explosion would cause disproportionate damage to these areas. A case study would also be a meaningful and impactful way to illustrate these scenarios, as trainees could learn about EJC's and gain knowledge about how to locate these facilities. Another area where OTA could increase aid would be to inform companies about flooding hazards and how to identify if they are in a flood zone. Our survey results showed that several companies are either unaware of flood risks, or

have not paid them enough attention. As climate change is only going to increase over the next few decades, companies should be trying to get a head start on climate preparedness. The OTA can help these facilities with their mapping tools, allowing manufacturers to see current and future flood risks in their areas.

5.3 Recommendation 3: *We recommend the OTA increase their business and community outreach.*

The results of this survey expressed that some companies might not know how OTA fully works, or might not be aware of the free services they provide. Companies can gain essential knowledge from OTA trainings, such as how to reduce the amount of pollution they produce, and the chemicals they use. Trainings from OTA also teach facilities how to improve their chemical safety and emergency preparedness, and climate change preparedness. If more companies are aware of OTA, then more companies may become aware of how to make their facilities and surrounding communities safer.

Through the Office of Technical Assistance and Technology's (OTA's) diligent and strenuous effort to make communities safer, companies have reduced toxic chemical use in Massachusetts to a 30 year low. That being said, there are new threats on the horizon. Climate change will have a major impact on day to day life, and especially on these manufacturers. Through training, touring, practice, and patience, OTA will continue to make Massachusetts a safer place to work, live, and enjoy.

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Appendix A- Survey

Introduction:

OTA is conducting this survey to learn more about the services and training opportunities that would help your company prevent the risk of industrial accidents related to the impacts of climate change, such as flooding, extreme heat/cold and extended power outages. This survey also covers the topics of emergency preparedness planning and toxic chemical use reduction. We greatly appreciate your time in taking this survey, as doing so will help us tailor our services to align with your company's needs. Not all questions in the survey may be applicable to your facility, and you may skip any questions you don't feel you can answer. This survey may take you between 15 to 30 minutes to complete.

Your survey link is specific to you. Please do not share it with anyone else. If you are interrupted while you are taking the survey, you may close out of it and your progress will be saved when you access the survey again using the same link. If someone other than you should be completing this survey on behalf of your company, please contact Kari.Sasportas@mass.gov.

~Page Break

Confidentiality:

This survey is being administered by OTA interns who are students at Worcester Polytechnic Institute (WPI). These interns are working under the same strict confidentiality agreement that applies to all OTA staff.

The survey is hosted on WPI's survey platform, but no identifying information about your company has been programmed into this WPI system—only a unique code that WPI interns can use to connect your survey responses to information about your company. No question in this survey requires you to provide identifying information, such as your company name. We encourage you not to self-identify in your survey responses.
Please be advised that if you do choose to disclose identifying information in your survey responses, you will be disclosing that information into a WPI system.

I understand that OTA has maintained my company's confidentiality in the design of this survey, and that my responses to this survey (including any identifying information I choose to disclose) are being submitted to a Worcester Polytechnic Institute system.

- Yes, and I agree to participate in this online survey (1)
- I would prefer to participate in a phone interview with WPI interns (2)
- I would prefer not to participate (3)

~Page Break

1. Is your facility required to submit any of the following relevant federal requirements?
    - Emergency Preparedness Citizen Right-to-know Act (EPCRA) Superfund Authorization and Reauthorization Act (SARA) Title III (1)
    - Resource Conservation and Recovery Act (RCRA) (2)
    - Clean Water Act – Spill Prevention, Control, & Countermeasure (SPCC) (3)
    - Chemical Facility Anti-Terrorism Standard (CFATS) (4)
    - Clean Air Act – Risk Management Program (RMP) (5)
    - Occupational Safety and Health Administration – Process Safety Management Standard (6)
    - Massachusetts Hazardous Materials Processing Regulation (7)
    - Don’t know (-1)

2. Has your company identified or evaluated sea level or flood zone risks relevant to the location of your manufacturing facility (check all that apply or enter N/A if not applicable):

- Current elevation from sea level at high tide (1)
- Current location in or near flood zone (2)
- Future elevation from sea level at high tide based on climate modeling scenarios (3)
- Future changes in area flood risk based on climate modeling scenarios (4)
- N/A (-1)

3. If yes, what is your company doing about the current and/or future threat?
4. Which of the following process(es) in your facility are dependent on a continuous power source to maintain safe operation?
    - Control temperature for a process or reaction (1)
    - Control pressure (2)
    - Prevent unintended release of chemicals (3)
    - Prevent mixing of chemicals (4)
    - Prevent backflow (5)
    - Emergency ventilation (6)
    - Computer process control (7)
    - Pollution control devices (8)
    - Other (List below) (9)
5. Is back-up power available for these processes? (Carry forward choices)
    - Control temperature for a process or reaction (1)
    - Control pressure (2)
    - Prevent unintended release of chemicals (3)
    - Prevent mixing of chemicals (4)
    - Prevent backflow (5)
    - Emergency ventilation (6)
    - Computer process control (7)
    - Pollution control devices (8)
    - Other (List below) (9)

~Page Break

6. Does your facility have an emergency generator?
   - Yes (1)
   - No (0) (Skip to 7)

6A. How many emergency generators does your facility have?

(Drop down menu, 1, 2, 3, 4, 5, 6, 7, 8+)

1, 2 ,3 ,4 ,5 ,6 ,7, 8

6B. What do you use to fuel your emergency generator(s)?

- Diesel (1)
- Natual Gas (2)
- Other (Please specify) (3)

6C. How long would your fuel supply last in an extended power outage (e.g., number of hours or days?)

6D. Is the location where the generator, or its fuel, stored in an area that may be susceptible to flooding (e.g., basement level; low lying outdoor area)?

- Yes (1)
- No (0)
- Unsure (-1)

6E. How often do you test your emergency generator(s)?

~Page Break

7. Does your facility maintain an emergency preparedness plan for facility employees that addresses any of the following:
   - My facility does not have an emergency preparedness plan (-1) (Skip to 8)
   - Charging, testing, or maintenance of any back-up emergency communication devices (e.g., radios, walkie-talkies, etc.) in the event of cell service or landlines being out (1)
   - Alternate staffing for absences of critical personnel due to emergency conditions (e.g., disruption in transportation services; dependent care at home; illness; etc.) (2)
   - Current contact information for city/town emergency management officials, local board of health officials, and/or appropriate state officials in the case of a chemical or biological release (3)

- Procedures for containing a spill or release (4)
- Maintenance, storage, testing, and availability of personal protective equipment (PPE) (5)
- Periodically checking expiration dates (where applicable) and/or rotate stock for PPE in storage (6)
- Storing items in a location that would remain clean and dry in case of flooding (7)
- Current list of company preferred PPE vendors and alternate vendors in case of an emergency supply chain shortage (8)
- Current full inventory list of chemicals stored on-site (9)
- Current SDSs for chemicals used or stored on-site (10)

7A. Regarding your emergency preparedness plan for facility employees, how often do you undertake exercises?

- Yearly (1)
- 1-3 Years (2)
- 4-6 Years (3)
- 7+ Years (4)
- Unsure (-1)

7B. Regarding your emergency preparedness plan for facility employees, how often is it updated?

- Yearly (1)
- 1-3 Years (2)
- 4-6 Years (3)
- 7+ Years (4)
- Unsure (-1)

~Page Break

8. Does your facility need assistance with any of the following aspects of emergency exercise planning or implementation:
    - Exercise design and evaluation plan? (1)
    - Developing realistic exercise scenarios related to chemical safety and climate risks? (2)

- Table-top exercises? (3)
- Functional or full-scale exercises? (4)
- Making connections with local or regional emergency planning agencies or municipal emergency managers to participate in relevant local or regional emergency exercises? (5)
- None of the above (-1)

9. Is your facility within one mile (1.6 Km) of an Environmental Justice Neighborhood?
   - Yes (1)
   - No (0)
   - Unsure (-1)

(If unsure) If you are unsure about your facilities' proximity to Environmental Justice Neighborhoods, visit OTA's mapping tool to learn more.

10. Is your company in conversations with any of the following?
    - Local Fire Department (1)
    - Local Board of Health (2)
    - Emergency Management / Emergency Response (3)
    - Local or Regional Emergency Planning Committee (4)
11. Would you like OTA to connect you to any of these stakeholders? (Display if not equal to 4, carry forward unselected choices from 10)
    - Local Fire Department (1)
    - Local Board of Health (2)
    - Emergency Management / Emergency Response (3)
    - Local or Regional Emergency Planning Committee (4)

~Page Break

12. Are emergency responders (e.g. Local fire department, Hazmat team) aware of chemicals that are present in your facility?
    - Yes (1)
    - No (0)
13. Have emergency responders (e.g. Local fire department, Hazmat team) toured your facility within the last 5 years?
    - Yes (1)

- No (0)

14. Among TURA chemicals in your facility, which are you the most concerned about regarding climate change? (Please list)
15. Do you have any other concerns that may not have been addressed in this survey?

~Page Break

16. Would you like an OTA staff member to follow up with you about your responses to this survey?
    - Yes (1)
    - No (0) (If No, skip to end of survey)
17. What is the best way to contact you? Please provide your preferred contact information.

- Phone_____
- Emil _____
- Other_____

End of Survey:

We thank you for your time spent taking this survey.

Your response has been recorded.

Appendix B - Interview Questions

Jennifer Hoyt / Jacob Nunnemacher

- What is your role at the Massachusetts Division of Fire Safety?
    - What are your primary responsibilities in this role?
    - How does the division of fire safety deal with hazardous chemicals? Are there any standard procedures that the entire Division follows if an accident happens?
- What do you (Jenn) do in your role as a member of the TURA Administrative Council?
    - How did you come to this position?

    - Why are you still in this position?
    - Has your experience as a council member changed how the Division of Fire Safety operates at all? If so, what changed have been made?
    - What knowledge from TURA, if any, has made your job safer?
- Ask the specifics of what you specifically do for the trainings for each company
    - What kind of trainings does the Department of Fire Safety deliver?
    - Why do your trainings cover the topics that they do?
    - Do you feel there should be an increase or decrease in the trainings being held? Why or why not?
    - Have these trainings you've provided touched on or helped with climate change in any way shape or form?
- Ask questions about the Department of Fire Services' relationships with companies, climate change adaptations, and amount the Department itself.
    - Does your experience with home escape plans help you when you work with large companies and emergency preparedness planning?
        - If not working on this, proceed to next question
    - Do you help companies stay within the laws set by Massachusetts and the State Fire Marshal?
    - What is the Department of Fire services suggesting companies do regarding climate change adaptation?
    - Does the Massachusetts Firefighting Academy discuss climate change in the training?

Cora Roelofs

- What is your role at the UMASS Lowell Research Facility at the Center for the Promotion of Health in the New England Workplace?
- What are your primary responsibilities in this role?
- What kinds of training do you provide and what is your target audience?
    - Do you, or someone in your facility, provide training to individuals?
    - If so, what kind of trainings do you cover?
    - Do you believe that information about climate change effects should be discussed more during the trainings?

    - Why should workers be concerned about climate change and in which way would this affect their work? Which kinds of dangers could they experience?
    - What should companies do to prevent these dangers?
- How do trainings help workers avoid harm in the workplace?
- How does Toxics Use Reduction help keep healthcare workers safer in the workplace?
- Has your research into workplace safety and health revealed anything alarming to you over the years? If yes, have these alarming characteristics been changed for the better?
- How does emergency preparedness in the healthcare sector differ from one that would be made for a manufacturer?
    - Have the results shown improvements in the workplace and/or contributed to how workers treat each other / workplace tools etc.?
    - How effective do you feel these trainings have been?
    - Do you feel there should be an increase or decrease in the trainings being held? Why or why not?
    - (Would you say that this should go out to as many companies as possible or be kept as exclusive as needed?) - not sure on wording

Thomas Estabrook

- The New England Consortium (TNEC)
- What is your role at the New England Consortium?
- What are your primary responsibilities in this role?
    - How do you announce or reach out to TURA filers to notify them of future training courses? How do you get new or uninformed groups to learn about your courses?
    - How many companies take advantage of your chemical safety courses?
    - TNEC says they are “able to custom design trainings to address the specific hazardous materials and other hazards at a client's work site”. How exactly do you go about this, both setting up the training and communicating with the client about their specific needs?

    - How often do companies attend trainings by TNEC, and if so, do you think that enough companies are attending them, and why?
    - Do you believe facilities are meeting the requirements for proper chemical / hazmat safety procedures, why or why not?
    - What is OTAs involvement in producing or hosting these training courses?
    - Are the effects climate changes discussed in the emergency preparedness trainings? If so, how important of an issue in the future do you believe it could become? If not, do you believe that it should be taken into consideration?
    - How often are the communities around the facilities taken into consideration during the trainings? Do you think they should be?
- Umass Lowell Project Director
    - What kind of research do you conduct as a project director?
        - How does it tie into the climate change items that you are involved with?
    - Have you noticed any changes to employee safety due to climate change?
    - Do you feel that climate change is becoming more of an issue?
    -

John Viveiros

- State Emergency Response Commission
- What is your role at the Massachusetts Emergency Management Agency?
- What are your primary responsibilities in this role?
    - How is climate change effecting how the State Emergency Response Commission handles spills or releases of hazardous materials?
    - Has the EPA's Emergency Planning Right-to-Know Act (EPCRA) been affected or changed by the impacts of climate change?
    - Have you experienced any chemical accidents that were caused by climate change?
    - Have there been any accidents that were harder to clean/ made it harder to protect the community due to climate change?
    - Have any tier II companies started to make adaptations to their facilities due to climate change?

    - How do local and regional emergency contact committees work with companies to stay safe when climate disasters happen?
- Massachusetts Energy Management Agency
    - I noticed that a large portion of the Safety tips on the MEMA Website appear to be related to natural disasters. Have recent changes in climate trends made these natural occurrences more dangerous for companies?
    - Do MEMA emergency alerts inform companies about incoming climate events?
    - Why should companies be concerned about climate change?
    - Do hazardous chemicals in large facilities make climate change more of a threat to our communities?
- What is SERC?
    - What does SERC do?
    - What do you personally do for SERC?
    - How do Tier II facilities work with local and regional Emergency Management, and SERC, to reduce the use of Toxic Chemicals? Does TURA directly aid tier II facilities?
    - Is SERC aware of changes in the climate? Are preparedness plans implementing climate change?

Michele Paul

- What is your role at the Office of Environmental Stewardship in New Bedford?
- What are your primary responsibilities in this role?
- How long did it take to arrive to such a fleshed-out plan for this preparedness plan in the sequence?
- How often do you put the plan in place / practice the plan?
    - Have you been able to make any refinements to the plan ever since it's been made?
    - Have you or your team members done any exercises during times such as hurricane season or needed to implement an emergency case especially in

hurricane season? Have they proven fruitful for what could save / improve the lives of those in New Bedford? How so?

- Will this plan be able to assist other communities beside New Bedford, or will this plan strictly work with and stay in New Bedford?
- Have you seen any improvements to the community members in New Bedford?
    - Whether you are or aren't, is there anything you hope to change or add in that may not be described on the website that details some of the resiliency plan?
    - Do you know where the diverted waste usually is placed, and do you know why the transferal is only at 37%? Is there a lot more than most people realized or is there not enough places to move the landfill, especially if a climate change incident were to occur? Are many companies filling these landfill locations and are you providing these companies with the best places to move the waste?
- Have there been industries or company representatives that attend your trainings?
- If so, have these companies had positive feedback for you? Negative?

Todd Dresser

- What is your role at Chubb Global Risk Advisors?
- What are your primary responsibilities in this role?
- https://massgov.sharepoint.com/:b:/r/sites/ENV-Saltonstall-WKGRP-Environment/ota/Interns/2022%20WPI%20IQP/Background%20documents/2017-2018%20Workshop%20Presentations/Emergency%20Planning%20101%20(Todd%20Dresser,%20ESIS).pdf?csf=1&web=1&e=VgKQFR
- Questions possibly pertaining to the presentation
- Do you work closely with the regulations that are a part of your presentation
- If so, do you give presentations alongside any of the administrators of these regulations?
- If not, have there been difficulties with doing so?
- Are employers usually unaware about any of the regulations presented to you? Which ones and why may this be?
- Is there any way to address this concern for why they may not know about these regulations?

- Do you think that climate change is something that should be included in the emergency planning?
- How often can these regulations conflict with a company and their ability to address climate change in their own way?
- What cities / types of cities within Mass have you found that have been most affected by climate change who would most benefit from these presentations?
- How important do you think an interaction between a company and its community should be?

Rick Ferreira

- What is your role in the city of Taunton, Massachusetts?
- What are your primary responsibilities in this role?
    - Does your position allow you the chance to advocate or implement policies that involve climate change protection and resiliency?
    - Do you feel there should be an increase or decrease in the trainings being held? Why or why not?
    - Have these trainings you've provided touched on or helped with climate change in any way shape or form?
        - Do you feel that it should be or can be better implemented? Further explain
    - What regulations do you have to follow that inspire you to refine/retain the mitigation plan?
    - How viable is the mitigation plan and have further adjustments been needed?
    - Who do these trainings best serve? Larger communities, smaller ones, ones that flood a lot, ones that flood very inconvenient amounts
    - On the Taunton Hazard Mitigation Plan, there are several examples of severe storms discussed. Do current climate trends concern you, and if so, how?
    - Have you experienced any chemical accidents that were caused by climate change?
    - Have there been any accidents that were harder to clean/ made it harder to protect the community due to climate change?

    - How do local and regional emergency contact committees work with companies to stay safe when climate disasters happen?
    - How has the town of Taunton been affected by climate change?

1. What do you cover in Taunton's Municipal Vulnerability Preparedness workshop?
2. In what areas is Taunton most vulnerable?
3. Do hazardous chemicals cause a threat to Taunton?
4. How have OTA and TURA made changes to the hazards in Taunton?

Chris Rascher

- U.S. EPA, Region 1
- What is your role at the EPA?
- What are your primary responsibilities in this role?
    - Has the EPA made changes to the list of chemicals managed by the Toxics Release Inventory due to climate change impacts?
    - (EPCRA) How are emergency preparedness plans being changed to adapt to climate change?
    - How does the risk management program's trainings discuss the impacts of climate change?
    - Have you experienced any chemical accidents that were caused by climate change?
    - Have there been any accidents that were harder to clean/ made it harder to protect the community due to climate change?
    - How do local and regional emergency contact committees work with companies to stay safe when climate disasters happen?
    - How many regions in Massachusetts do you feel face an immediate threat to climate change disasters?
    - How can communities become more prepared for disasters due to climate change?
    - How are local fire departments adapting to climate change?
    - Did OTA/TNEC Climate Change, Chemical Safety, and Resilience training in May 2022 change your mind or make you realize anything about the risks of climate change?

        - What did you do in your breakout session? What did you enjoy? Did not enjoy?
- Ask questions about the specificities of RMPs for companies
    - How does RMP work in relation to you and other companies?
        - Is there a way to tie it into climate change or is this not how RMP works?

Appendix C - Consent Letter

Informed Consent Agreement for Participation in a Research Study Investigators: Blake Currier, Alex Marrinan, Jada Smith, Wassim Faker, Joel Brunzell

Contact Information: jbrunzell@wpi.edu, ammarrinan@wpi.edu ,whfakerelkazzaz@wpi.edu ,jsmith6@wpi.edu, bhcurrier@wpi.edu

Title of Research Study: Chemical Safety and Climate Change Resiliency

Sponsor: Office of Technical Assistance and Technology

Purpose of the study: The purpose of this study is to gather information on the current state of the OTA's training materials for safe toxic or hazardous chemical management, and climate change resiliency. We will conduct this study through surveys and interviews.

Procedures to be followed: The procedures to be followed are to take the survey provided by the Chemical Safety and Climate Change Resiliency team. We will ask specific individuals for personal interviews as well.

Risks to study participants: There is a possibility that some questions may cause discomfort to participants, as the questions are related to the companies they work for.

Benefits to research participants and others: The benefit to the researchers will be to find areas where current OTA trainings lacks, in relation to chemical safety and climate change adaptations. We will then be able to propose potential changes to training materials, which could improve safety in facilities that handle hazardous chemicals.

Record keeping and confidentiality: We will collect the results of the surveys and interviews to improve our research and better understand current training practices in facilities that handle hazardous chemicals. Records of your participation in this study will be held confidential so far

as permitted by law. However, the study investigators, the sponsor or its designee and, under certain circumstances, the Worcester Polytechnic Institute Institutional Review Board (WPI IRB) will be able to inspect and have access to confidential data that identify you by name. Any publication or presentation of the data will not identify you.

Compensation or treatment in the event of injury: There will be no compensation for participants in surveys or interviews. You do not give up any of your legal rights by signing this statement.

Cost/Payment: N/A

For more information about this research or about the rights of research participants, or in case of research-related injury, contact: jbrunzell@wpi.edu, ammarrinan@wpi.edu ,whfakerelkazzaz@wpi.edu , jsmith6@wpi.edu, bhcurrier@wpi.edu

Your participation in this research is voluntary. Your refusal to participate will not result in any penalty to you or any loss of benefits to which you may otherwise be entitled. You may decide to stop participating in the research at any time without penalty or loss of other benefits. The project investigators retain the right to cancel or postpone the experimental procedures at any time they see fit.

By signing below, you acknowledge that you have been informed about and consent to be a participant in the study described above. Make sure that your questions are answered to your satisfaction before signing. You are entitled to retain a copy of this consent agreement.

_____

Study Participant Signature

Date: _____

_____

Study Participant Name (Please print)

_____

Signature of Person who explained this study Date: _____

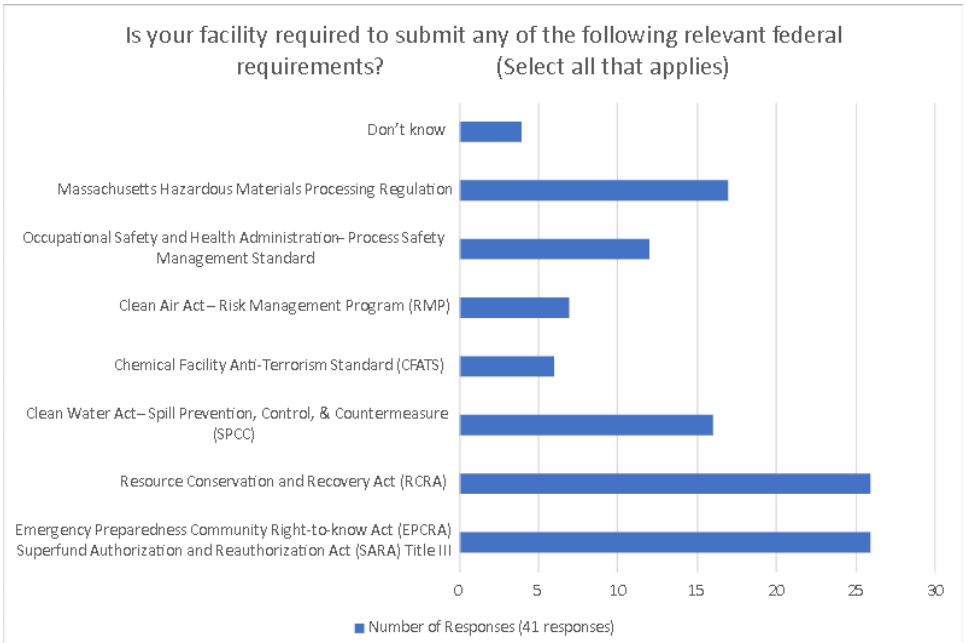
Additional clauses:

Significant new findings or information, developed during the course of the research, may alter the subject's willingness to participate in the study. Any such findings will be promptly communicated to all research participants.

Special Exceptions: Under certain circumstances**,** an IRB may approve a consent procedure which differs from some of the elements of informed consent set forth above. Before doing so, however, the IRB must make findings regarding the research justification for different procedures (i.e. a waiver of some of the informed consent requirements must be necessary for the research is to be "practicably carried out.") The IRB must also find that the research involves "no more than minimal risk to the subjects." Other requirements are found at 45 C.F.R. §46.116.

Appendix D

Figure 23: Graph of facilities federal requirements



Appendix E

Population and Major Industries of Boston

The greater Boston Area has a population density of 14,000 people per square mile, with an estimated population of about 700,000 residents (United States Census Bureau). Such a densely populated area only increases the need to keep the city safe since even a relatively small natural disaster or chemical explosion could cause massive damage. These damages could result in being held inside your home until a chemical threat is gone or direct damage to either buildings or individuals. Making sure that keeping their chemicals safe will, in turn, support the population of Boston safe as well. And this will be necessary since Boston is a significant provider of chemical product manufacturing.

The largest industries in Boston are healthcare, finance, insurance, and higher education. While manufacturing only makes up about 1% of working citizens in Boston (Blake et al., 2011), the second highest manufacturing field is chemical products, only behind computer and electronics products (National Association of Manufacturers). In 2017, $9.5 billion was made from chemical product manufacturing in Massachusetts, where most of these products were made in Boston (National Association of Manufacturers). Overall, Boston has many industries that are at risk for chemical disasters, and climate change will only make that risk even higher.