6-26-2024

Natural Hazards Triggering Technological Disasters: Source Identification, Vulnerability, and Evaluation of Emergency Preparedness in a Southern California City

Lisa Peumsang
Walden University

Walden University

College of Health Sciences and Public Policy

This is to certify that the doctoral study by

Lisa Curtis

has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

Review Committee
Dr. Julian Muhammad, Committee Chairperson, Public Policy and Administration Faculty
Dr. Michael Brewer, Committee Member, Public Policy and Administration Faculty

Chief Academic Officer and Provost
Sue Subocz, Ph.D.

Walden University
2024

Abstract

Natural Hazards Triggering Technological Disasters: Source Identification, Vulnerability, and Evaluation of Emergency Preparedness in a Southern California City

by

Lisa Peumsang

MS, Walden University, 2018

BA, University of California Los Angeles, 1997

Professional Administrative Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Public Administration

Walden University

August 2024

Abstract

Natural hazards triggering technological disasters (natech) events exist around the world and affect people, infrastructure, the economy, and environment but are not often considered for local hazard mitigation and emergency preparedness plans. The purpose of this qualitative case study was to identify (a) the natech event vulnerability of the target city, which is in the western United States, and potential sources for these events and (b) the extent to which the city's hazard mitigation and emergency operations plans addressed natech events. The vulnerability assessment was performed through the lens of network risk theory and involved secondary data analysis of publicly available reports from the U.S. Environmental Protection Agency's (EPA) website. The vulnerability assessment incorporated cross-referencing and mapping of EPA data, application of a natech event vulnerability tool to data of chemical releases from industrial sites withing the city, previous experience with threat and hazard identification experience, and deductive analysis of the city's current plans. The city was found vulnerable to natech events due to the presence of petroleum refineries, bulk stations, and terminals near locations identified as critical functions for the city's emergency response capabilities. Recommendations include positive social change through conducting a risk assessment of natech events for the next hazard mitigation plan. Identification and mitigation of potential natech event impacts may extend benefits beyond the local government to include the private sector, critical transportation infrastructure, the economy, and well-being of emergency services responding in mutual aid.

Natural Hazards Triggering Technological Disasters: Source Identification, Vulnerability, and Evaluation of Emergency Preparedness in a Southern California City

by

Lisa Peumsang

MS, Walden University, 2018

BA, University of California Los Angeles, 1997

Professional Administrative Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Public Administration

Walden University

August 2024

Dedication

For Jake, who has never left my side.

Acknowledgments

I would like to express my sincerest gratitude to my Chair, Dr. Julian K. Muhammad, for his guidance and support of my research and efforts toward a doctorate in public administration. To Dr. Linda-Marie Sundstrom and Dr. Michael Brewer, thank you for the diligent review and recommendations to ensure the methodology met the high standards requisite for the program and Capstone. Additionally, I am very grateful for the form and style expertise of Dr. Tara Kachgal.

To an incredible circle of friends who have surrounded me with support, laughter, and long conversations about life – thank you. Lee, Lara, Alyssa, Rin, Maggie, Liz, Abbiola, Joanna, and Kelli – you know just how meaningful this journey has been to my family and me and you have been with us through it all. To those who are dear friends as well as professional mentors, I continue to learn from you as I pursue daily improvement as an emergency manager and public servant. Eric Baumgardner, thank you for being there from day one in my career as an emergency manager and laying the foundation for my role to "protect the jurisdiction". To Chief Greg Murphy and Chief Fred Fernandez, thank you for your incredible support in my pursuit of this degree to go along with the Queen of Doom.

None of this would have been possible without the love, encouragement, and unwavering faith of my family. Laura and Roger, I would not be able to do what I do without the two of you. To my pack for their endless joy and comfort. Thank you to my mom for boundless love. To Daddy – you are still driving me. To my children, Sypha and Cori, all of this is for you and a safer world in which you can flourish.

Table of Contents

List of Tables

List of Figures

Section 1: Introduction

Natural hazards triggering technological disasters (*natech*) describes the cascading disasters, triggered by natural hazards such as floods, earthquakes, tsunamis, and fires, that affect industrial installations (Pilone et al., 2022). Though natech disasters have been referenced in academic and industrial literature as early as the 1990s, it was not until changes to the European Union's Seveso Directive in 2012 that awareness of these events garnered traction among public administrators impacted by the directive across all levels of government (Necci & Krausmann, 2022). Researchers have addressed a variety of natech events ranging from those triggered by floods to earthquakes to tsunamis, the compounding issues presented by the impacts of climate change, and the challenges those responsible for industrial installations may face in addressing natech risk assessment and management (Necci & Krausmann, 2022).

Risk assessments of threats and hazards are a fundamental element of emergency management planning and preparedness. These assessments inform processes and procedures for response, first responder safety, evacuation needs, and alert and warning (Federal Emergency Management Agency [FEMA], 2017). In the United States, natech events are not commonly identified as threats and hazards addressed in local emergency operations and hazard mitigation plans, which tend to focus on initial over cascading events (U.S. Department of Homeland Security, 2018)

The purpose of this qualitative study was to identify the natech disaster vulnerabilities and associated risks to the target city, which has a large amount of industrial and chemical plants located within its jurisdiction. I identified potential sources

of natech events and the city's vulnerability to these events by analyzing existing data from the U.S. Environmental Protection Agency (EPA) and documents provided by the client city. Natech risk assessment tools from Pilone et al. (2021) were utilized as part of the analysis to identify the extent of natech vulnerabilities within the city. This study may provide insight on unknown or insufficient risk identification within the city and improve awareness of planning and preparedness for natech events. The city's current emergency operations plan (EOP) and local hazard mitigation plan (LHMP) did not account for natech events and disasters. The natech disaster vulnerability identification and risk assessment performed as part of this study may support hazard identification for the LHMP and stakeholder decisions related to mitigation opportunities, first responder trainings, and infrastructure planning. The findings may also encourage leaders of other U.S. cities and counties to address their natech risks and evaluate their respective plans for efficacy. Within the larger field of public administration, the study may support future emergency management centered natech research in the United States and related policies and procedures at the local level.

Organization Background and Problem Statement

In the United States, state and federal guidance for natech risk assessment and emergency preparedness is insufficient, thus leaving local municipalities without tools or methodologies to identify and address potential vulnerabilities (Santella et al. 2018). Legislation and guidance for natech events and emergency preparedness within the State of California does not exist, based on my review of the literature. California is subject to numerous and planned for threats including earthquakes, flooding, and wildfires

(CalOES, 2021). These events may trigger explosions or loss of containment of hazardous materials (Pilone et al., 2021). Atmospheric river storms are causing disastrous and sometimes catastrophic events across the state (Masters, 2023). As these storms increase in frequency and intensity, infrastructure supporting flood control may be compromised (Swain et al., 2018). Industrial facilities built for regions that have not previously been identified in flood-prone regions may now and in the future be subject to flood-induced natech events. According to Yang et al. (2020), floods and lightning are responsible for the start of most natech events.

Natech events are cascading events that stem from a naturally triggered event. These events are likely to slow critical life-saving response as resources, personnel, and equipment are allocated to others within the municipality (Santella et al., 2011). The city has an obligation to a residential population of over 95,000 people (U.S. Census Bureau, 2022). City leaders have not addressed natech events in their EOP, and its LHMP does not address the risk of cascading events. The city's 2013 LHMP identifies natural hazards and focuses on each identified hazard as a standalone threat. local business journal identified oil, gas extraction, mining, and quarrying as key industries within the city. Located in the city is a 400-acre oil distribution facility that receives and distributes fuel transported by truck and pipeline for Southern California (Shell, n.d.). In 2022, the city experienced a range of industrial events including an odor emission requiring a state of emergency and a spill of over 9,000,000 gallons of raw sewage (Mahoney, 2022).

This study may inform city leaders of natech vulnerabilities to address in future emergency management plans and procedures. Providing leaders of a local municipality

with a method to identify natech risks and assess for their vulnerability to these events may be duplicated in process and use of tools by other municipal leaders with industrial plants or chemical storage facilities within their jurisdiction. The study may also inform future research and discussion for how emergency management personnel and government officials assess disaster risks as individual events or in combination with the potential for networked events that change the landscape of response. These changes may promote calls for new policies at different levels of government and advance discussion for broader attention to natech event risks to the United States.

Purpose

The purpose of this qualitative study was to screen for potential natech sources, identify vulnerabilities to these events, and assess the current level of natech emergency preparedness within the city. At the time of this study, the city had 175 industrial sites within the city perimeter and hundreds more adjacent to the city. Failure to understand the risk associated with natech events may result in negative or even catastrophic impacts to life safety, critical key infrastructure, local and regional economic stability, and the environment. I analyzed the city's existing emergency plans and programs through the lens of the study's identified vulnerabilities and capacity to address potential risks. The study's findings support revisions to the city EOP and inclusion of natech disasters in the LHMP.

Guiding Questions

The research questions (RQs) for this study were

RQ1: What are the current sources and vulnerability levels of potential natech threats in the city based on the assessment tools in Pilone et al. (2021)?

RQ2: To what extent have identified natech threats and vulnerabilities been addressed in the city's current emergency preparedness and LHMPs?

Organizational Gap

This study may contribute to city leaders' understanding of the threats the city faces relative to natech incidents and the vulnerability based on current mitigation plans and was provided with a natech risk assessment process for emergency operations and hazard mitigation planning use. At the time of the study, city leaders employed a linear and singular approach to identifying threats and hazards in their LHMP. This study provides detailed insight on the city's vulnerability to natech events due to the presence of natural hazards and volume of content of hazardous industrial chemicals throughout the city. I presented the study's findings to the city's emergency manager to support revision of its LHMP with consideration to include natech events. The city's emergency management office was provided with a natech vulnerability assessment and vulnerability workflow that can be replicated in the future. Employing this process as part of the city's hazard identification may support improved situational awareness and currency for revisions to plans and procedures.

Summary of Data Sources and Analysis

For the qualitative analysis performed in this case study, I used the city's current emergency planning and hazard mitigation documents, hazardous chemical inventory reports, and Toxic Release Inventory (TRI) reports. The analysis enabled me to develop

recommendations for changes to the city's emergency operations and LHMPs. Document review of the city's 2021 EOP and its latest approved LHMP from 2013 provided a baseline for whether city leaders identified and addressed the threat of natech events. The hazardous chemical inventory was sourced from the data required of businesses to report by the Emergency Planning and Community Right-to-Know Act of 1986. Identification of the jurisdiction's vulnerabilities for natech incidents and how these are addressed in current emergency management plans can inform the decision-making related training content for emergency management and the city's developers and first responders. The client will also be provided with a tool to continue identifying its natech incident vulnerabilities.

Definitions

Emergency management: The managing entity charged with developing and executing systems, plans, and procedures to protect communities through mitigation, preparedness, response, and recovery.

Emergency operations plan (EOP): The guiding document that establishes the framework, procedures, and authority by which leaders of a government entity, organization, or business guide emergency response and recovery efforts.

Local hazard mitigation plan (LHMP): A plan that documents identified natural hazards within a jurisdiction and associated vulnerabilities to support effective mitigation efforts to minimize loss of life, injury, and damage to infrastructure and the environment.

Natural hazards triggering technological disasters (natech): A descriptive term for a cascading event, technological or industrial, that is triggered by a natural hazard (Kraussman & Necci, 2021).

Threat and hazard identification risk assessment (THIRA): At the community level, a risk assessment requires identification of threats and hazards to determine the capabilities needed to address associated risks.

Significance

This study is potentially significant because it will inform of unknown or insufficient risks to the people and environment within the city and enable improved awareness of, planning, and preparedness for natech events. Businesses, government entities, residents, and those who work and travel within the city may benefit from an enhanced understanding of natech threats and vulnerability. Of the government entities, the office of emergency services will have data-driven information to support its LHMP and a process to use in the future to maintain currency of natech data. City entities can potentially use this information in their work with businesses and other stakeholders including hospitals and assisting agencies for disaster response. The culmination of better informed and prepared emergency responders and government officials can have a direct impact on the people within the city before and during a natech event. The findings of this study have the potential to yield positive social change by providing leaders of cities and counties with a tool and process to address their natech risks and evaluate their respective plans for efficacy. The study may also support emergency management

focused natech research in the United States that can inform addressing natech events in national guidance documents and procedures.

Summary

My goal in conducting this qualitative case study was to identify the target city's natech event vulnerability and level of preparedness relative to emergency plans and mitigation efforts. This case study will inform the city's vulnerability to natech events and the gap in existing emergency management plans using a qualitative assessment of publicly available data.

Though natech events are not new, literature relative to many other causes of emergency events and disasters is minimal, according to my review of the literature. In Section 2, I provide greater detail regarding what is known about natech events and the importance of applying network theory when considering risk, vulnerability, and the value to emergency management planning. Gaps in existing research present an opportunity for this study's focus in the field of emergency management at the local government level. This study's findings may inform future emergency management planning and mitigation efforts in a city where a natech event may result in significant consequences for its residential population and many industrial companies situated there.

Section 2: Conceptual Framework and Relevant Literature

Introduction

Guidance for understanding and accounting for natech events within emergency management planning and risk assessment is not provided to local jurisdictions by the State of California. The client city has an abundance of industrial companies, and the region is subject to naturally occurring hazards and an increase in storms due to climate change. This qualitative case study will provide the city with an improved understanding of its natech event vulnerability and how current plans address natech event preparedness. This section addresses findings from scholarly research on natech events and the relationship to this study. Also addressed are literature specific to network theory and linear theory as relevant to risk assessments for emergency management planning.

Literature Search Strategy

I searched for peer-reviewed academic studies to include those presenting and incorporating a natech event vulnerability tool. Academic and professional databases searched include but are not limited to EBSCOhost, ScienceDirect, International Security & Counter Terrorism Reference Center, JRC Publications Repository, and Journals@OVID; these databases were accessed through Walden University's Library. Search engines included Google Scholar. Additional emergency management documentation was sourced from the city's website. Most of the literature reviewed in this study was published within the last 5 years, though a couple of articles relevant to the history of natech events predate 2018. Key search terms included *natech*, *natech disaster*, *natech vulnerability*, *natech risk*, *network theory*, and *linear theory*.

Conceptual Framework

The conceptual framework for this case study connects scholarly literature on natech events, including calls for entities to address these events in their planning efforts and tools to identify associated vulnerabilities, to the need for networked risk assessment in local government emergency management plans. The history of natech events, rate of occurrence, and impact of levels of preparedness will be presented. A natech vulnerability tool developed by Pilone et al. (2021) was incorporated into the case study to identify the city's natech vulnerabilities. The tool was designed to provide local administrators with a survey of vulnerable sites and substances within the city and, through qualitative analysis, assign potential natech event vulnerability ratings. The client city's emergency planning documents were analyzed to identify existing gaps in threat identification relevant to natech event vulnerability.

Literature Review for the Study

The risk of natech events commenced with the onset of the industrial revolution. Academic study of natech disasters began in the mid-1990s (cite UNDRR Showalters and Myers, 1994. A 2004 study identified the potential for significant risks to unprepared areas including identification at the local level. This early study presented the primary challenges with risk management and emergency response and potential risk reduction methods (Cruz et al., 2004). Referencing case studies including the 2002 floods across Europe that triggering a chlorine release in the Czech Republic, the authors presented recommendations including natech-specific emergency planning and risk reduction (Cruz, 2006).

While initial studies and discussions across various stakeholders centered around European countries, Santella et al. (2011) conducted research in the United States providing a quantitative assessment of the conditional probabilities associated with natech events at facilities impacted by hurricanes and other naturally occurring events. Using existing data on hazardous material releases that had natural event origins, the authors calculated the probability of hazardous material releases at facilities when exposed to a particular natural hazard of estimated intensity. The authors posited that the conditional probability of natech events due to earthquakes may present similar levels of risk to society necessitating mitigation efforts and legislative focus in those areas subject to seismic activity.

As natech event identification and research continued from a risk perspective, the European Union modified its Seveso Directive in 2012 to include natech event risk management for industrial facilities and sites in their respective reports detailing risk management, site safety, accident prevention, internal emergency planning, and requirement to provide this information to external stakeholders overseeing emergency planning (European Union, 2020). The updated Seveso Directive is cited in cases studies of natech events throughout Europe, various risk assessments of different facilities and hazardous materials storage containers, and proposed methods and tools for advancing the integration of natech event preparedness beyond industrial sites and their internal stakeholders (cite some studies from Krausmann and Pilone).

In 2017, Krausmann et al. made recommendations to the field of emergency management which included understanding the following:

- natural-hazard trigger
- safety barriers
- hampering of response operations
- domino risk
- response resources and psychological aspects

The authors stated that including natech events in emergency preparedness may change existing emergency plans for evacuations and shelter in place and the necessity for assessing emergency resource vulnerabilities during these events. Emergency response differs as the cascading elements of a natech event unfold in an environment where resources, infrastructure, and communication systems may be further compromised due to the triggering natural incident and possible simultaneous cascading events (Ricci et al., 2022). This has resulted in slower and delayed emergency response at times coupled with restrictions to incident sites (Pilone et al., 2022).

Current State of Natech Events in Research and Practice

Understanding what defines a natech event and whether a jurisdiction is vulnerable to these events is scarce in the United States and elsewhere. Though these events continue, with an increase in frequency tied to climate change, how private and public entities prepare for the impacts is hindered on several fronts. Making efforts more challenging is that current data for natech events is primarily connected to earthquake hazards (Pilone et al., 2022).

Societal knowledge and treatment of natech events is further challenged by the continued characterization as black swan events (Krausmann & Necci, 2021). Black swan

events are defined as events that are not predictable and exist as outliers and beyond the scope of management. Krausmann and Necci (2021) argued that natech events are not black swan events but rather failures of risk management among different stakeholders and a simplification of risk from an approach that is linear and sequential. The perception that an event is an "Act of God" relieves stakeholders of risk ownership inclusive of mitigation and emergency preparedness. natech events, with originating natural hazard triggers, are not such acts but rather a "a class of cascading events that manifest with nature and technological worlds collide" (Kraussman and Necci, 2021, p. 3). This requires emergency management to address both the natural and technological components of natech events in risk assessments and emergency planning. This is challenging due to the complexity of risk assessments, including industrial site reluctance to analyze for these events and the slow process for conducting risk assessments amid multiple stakeholders, lack of a strong natech event knowledge base, changes to data, and a lack of a unifying requirement to do so (Kraussman & Necci, 2021).

Increasingly, academic attention and research on natech events corresponds to the increase in climate change (Pilone et al., 2022). Like other natural events, climate change driven incidents occur in the absence of human-prescribed boundaries and despite an understanding that these events encompass multiple disciplines across all levels of government, much of the impact and response requires local response (Pilone et al., 2021). Understanding the risk of natech events for the purpose of emergency response planning demands a solid comprehension of the likely causes (Ricci et al., 2022). Developing policy and improving planning and response for natech events necessitates

participation from a collective group of stakeholders in this space which is not currently occurring (Pilone et al., 2021).

Risk cannot be fully eliminated necessitating a call for natech emergency preparedness with an understanding that these events are different from those technological or industrial in origin and the triggering natural event itself (Krausmann, 2017). Understanding and planning in response to the risk to natech events is nuanced and requires a different approach to disaster risk assessment. At the local level, this call is further hindered by the gathering of data specific to various sites in an environment that may not be aware of the risk or need to address mitigation and include natech events in emergency plans (Pilone et al., 2022).

Standard Practices Previously Used to Address Disaster Risk

Approaching disaster risk beyond a linear approach and developing network-based risk assessments is a challenge for those across the public and private sectors (Clark-Ginsberg et al., 2018). The authors further posited that disaster risk assessment can incorporate both linear and network approaches and incorporate assessing vulnerability in cascading disasters events (Clark-Ginsberg et al., 2018). This included finding risk assessments of cascading incidents conducted linearly, failing to recognize the network of systems from which that risk is created to include vulnerability (Clark-Ginsberg et al., 2018).

Natech events impact societies, economies, and the environment around the world (Krausmann, 2017). The events carry an amplified vulnerability depending on the likelihood of impact to a jurisdiction including the social, economic, and psychological

well-being of residents, workers, and neighbors. Despite thousands of these events, current programs and regulations in the United States are limited by the complexity of approaching disaster The challenge of addressing vulnerability and risk of natech events in the United States may be hindered by awareness of vulnerability and the strict categorization of what defines a threat.

Threat Identification and Risk Assessment in the United States

Local and state jurisdictions in the United States are encouraged to engage stakeholders from both the public and private sectors, including subject matter experts across various fields, to identify threats and hazards, assess risks, and close the gaps on prioritized threats in what is referred to as the THIRA process (FEMA, 2018). The identified priorities and subsequent attention to associated risks are expected to increase the jurisdiction's capacity to prepare, protect, mitigate, respond, and recover from a significant incident (FEMA, 2018). The resources and training associated with identifying likely threats and hazards places incidents in one of three categories: Natural, Technological, and Human Caused (FEMA, 2018). There is not an allowance within the THIRA process to assess the risk of an event that is the crossover between natural and technological.

Natech Risk Identification and Assessment

In 2006, Cruz et al. called for including natech events in emergency preparedness planning citing a 2003 workshop within the European Community aimed at understanding these events though historical case studies, gaps in awareness and prevention, and the potential for significant damage to participating countries'

communities, industries, and environments. Determining the probability of natech events was addressed a few years later in a study with site-specific quantitative studies to identify vulnerabilities of different industries and their equipment (Santella et al., 2011).

Natech Tool for Local Planners

In 2021, Pilone et al. presented a tool to be used by urban and local planners including those in emergency management to understand a local jurisdiction's awareness and preparation for natech events. The authors stated that the absence of local awareness and assessment has the potential for dangerous consequences for the jurisdiction and its population. Their study focused on the awareness and preparation of land use planning entities at the local level within the European Union with data incorporated from events and impacts from some natural and industrial hazards. The findings of their study acknowledged the challenges local level governments face in the absence of or complexity involved in directing policies and allocating responsibilities. Additionally, local governments lack resources including those who could speak to the technical capacity to plan and respond to natech events. Last, the authors' findings relevant to their European Union studies echo requirements in the United States to maintain currency of hazard identification, risk assessment, and emergency preparedness planning.

Pilone et al. (2021) developed their tool to efficiently identify possible natech event sources and industrial vulnerabilities, advance natech awareness within a jurisdiction, and assess land use tolerance to natech events within a jurisdiction. The tool included a checklist to identify potential natech vulnerable sites and the presentation of natech event scenarios and the potential for respective impacts. Additional components

incorporated quantitative and semiquantitative assessment of data from industrial sites related to their storage practices and facilities and previous incidents. In 2022, Pilone and two of the authors from the 2021 study applied their natech indicator at the local level in the European Union with the purpose of providing an easy method of identifying potential natech event risk to enable protective measures. The application of their natech tool or indicator in this case study found that local land use planners and decision makers were not aware of natech events prior to the study and that the tool can function as a first step for natech event awareness and possible vulnerabilities within their jurisdiction.

Summary

Though advancing in academic research, the functional application of studies to date within the field of natech event research and emergency planning continues to be scarce. Studies supporting the identification of potential sites of natech events, and their corresponding vulnerabilities and risks, has greater prominence within European countries with factors such as lack of awareness and the practice of labeling such events as black swans impacting how those assessing risk are challenged globally. Employing a tool designed for implementation at the local level can enhance the ability of local planners and decision makers to include natech events in the United States in their threat identification and risk assessment processes. This case study merged components of the natech event indicator and threat identification from the established THIRA process and identified possible threats of natech events to a city. The study also assessed the LHMPs for the identification of associated risk and inclusion in the city's EOP.

Section 3: Data Collection Process and Analysis

Introduction

The industrial facility heavy city in Southern California may be prone to natech events, which are increasing globally with climate change stimulating natural hazards such as atmospheric rivers and resulting floods (Masters, 2023). Per its website, the city has not updated its LHMP since 2013. Other plans, including the city's EOP, may not address the potential threat of a natech event. Additionally, those engaged in threat and hazard identification at the local level may not be aware of natech events and the possible ramifications to the jurisdiction and the community. Through document analysis and application of some of the data to natech vulnerability tool, a qualitative assessment was made to determine if recommending natech events be added to the city's list of identified threats and hazards and addressed in the city's emergency preparedness plans. This section incorporates the study's practice-focused questions and research design, role of the researcher and client organization, methodology, strategy for data analysis, issues of trustworthiness, and ethical procedures.

Practice-Focused Research Questions and Research Design

This qualitative study included document review and a secondary data analysis. The research design was rooted in applying an indicator tool, developed specifically for natech event identification, with an objective of supporting the city's threat and hazard identification for emergency preparedness planning purposes.

Research Questions

I sought to answer the following RQs:

RQ1: What are the current sources and vulnerability levels of potential natech threats in the city based on the assessment tools in Pilone et al. (2021)?

RQ2: To what extent have identified natech threats and vulnerabilities been addressed in the city's current emergency preparedness and LHMPs?

Justification of Deliverable

Identifying if the city is vulnerable to natech events will support the city's requirement to understand the risks the city community faces (FEMA, 2018), If natech events are found to be a viable threat or hazard, this study will provide data and analysis to support content update of the city's LHMP and revision to its EOP. The findings from this study may also inform the city's threat hazard identification and risk assessment process and future training content for first responders and emergency operations center staff to understand, coordinate, and respond to natech events.

Research Tradition and Method

I drew from the Pilone et al. (2021) natech indicator tool as well as the practice of identifying potential natech scenarios to assess whether the target city was vulnerable to these events. The researchers sought to identify vulnerabilities and in a European community to inform local land use planners of natech event vulnerabilities and provide data to support further risk assessment and planning. I selected the tool because it was designed specifically for local managers for urban jurisdictions whereas other methodologies for natech event risk assessment have approached risk from the perspective of industrial regulating authorities or industrial company leadership (Pilone et al., 2021). After analyzing data to identify whether natech event vulnerability exists, I

provided a report to the city's emergency manager containing information on associated gaps in current emergency preparedness and LHMPs. I also provided recommendations to minimize these gaps.

Roles of the Researcher and Client Organization

Currently, I am the director of emergency management for a 4-year state university in California with 7 years of emergency management experience in higher education and 2 years at the local municipal level. At the university where I work, I serve as an academic committee member for the graduate program in homeland security. Additionally, I am an adjunct professor for a different university's Master of Public Safety program where I teach the course Developing and Implementing Systems of Emergency Preparedness. My academic foundation in emergency management began with the master's program in emergency management at Walden University. My practical foundation in emergency management was garnered at the local level supporting a Southern California city's emergency management division out of its fire department. During that time, I rewrote that city's EOP and revised the LHMP for public review and comment.

In addition to emergency operations and LHMP review and revision, I have experience in exercise planning, incident response for dynamic incidents including wildfires, emergency operations center staff training, and policy group guidance. Furthermore, I coordinated an emergency operations center for 2 years in response to the COVID-19 pandemic. The emergency manager for the client city was previously employed at one of the state universities within the same higher education system I have

been employed with for 6 years. She and I worked as peers and would collaborate alongside approximately 21 other state university emergency managers. She left her university role to become the emergency manager for the client city, which is where her former university is located. Neither of us has held a supervisory position over the other or worked in the same jurisdiction nor has either of us served as an instructor for the other.

With a focused interest in natech events, I understand that I may have a bias that leans toward the existence of this threat and the vulnerability that is associated with it. As an emergency manager, I view global natech events with greater interest. In a qualitative study, it is not possible or desirable to separate the researcher from the analysis (Galdas, 2017). What is important, rather, is that "the researcher has been transparent and reflexive…about their own preconceptions, relationship dynamics, and analytic focus" (Galdas, 2017). To diffuse aspects of personal bias, I was cognizant to refrain from information bias during the data collection process through the employment of data verification, careful classification, and a reevaluation of coded data. The coding process is detailed later in this section.

Methodology

I analyzed data from various sources to answer the study's two practice-focused questions and provide deliverables to the client. The data for this study included emergency preparedness planning documents and government reports specific to industrial facilities within the city. Federal government reports for hazardous materials for the city were obtained from the following sources: TRI, Integrated Compliance

Information System for Clean Air Act Stationary Sources (ICIS-AIR), Superfund Enterprise Management System (SEMS) Search, Resource Conservation and Recovery Act Information (RCRAInfo) Search, Cleanups in My Community, and Toxic Substance Control Act Search. The assessed planning documents were the city's current LHMP and EOP.

The hazardous materials reports provided the data to inform the natech vulnerability tool checklist from Pilone et al. (2021). After entering the relevant data into the natech vulnerability tool, I assessed the data to provide insight on the city's current sources and vulnerability levels of potential natech threats. The city's LHMP and EOP reflect the extent to which city leaders have identified any natech event threats and vulnerabilities that guide emergency preparedness and response. The hazardous materials data fulfilled the needs of the natech indicator tool checklist for vulnerability at the local level from Pilone et al.'s 2021 study and informed if the city should consider further risk assessment. Assessment of current plans revealed if the city had identified natech events as a potential threat prior to the study. I followed various steps to organize the data collected for this study. Using the conceptual framework as the guide, I took the following steps:

- developed a plan based on the conceptual framework presented in Section 2,
- maintained a journal to document the data collection and analysis process,
- utilized Google Drive as a data collection tool with a consistent file nomenclature system to identify and retrieve data in an efficient manner,
- developed key insights using deductive analysis, and

- coded data and maintained and a code library for efficiency and to minimize loss of supporting evidence, and
- sorted data hierarchically top down from insights to themes to codes within a spreadsheet maintained in Google Drive.

Greater detail is provided under the Strategy for Data Analysis subsection.

Archival and Operational Data

Existing data and resources used for this study were comprised of federal reports regarding hazardous materials in the city, the city's 2013 LHMP, and the city's 2021 EOP. All of the hazardous materials reports were publicly available and generated through the EPA's website in accordance with the Emergency Planning and Community Right-to-Know Act of 1986; the Resource Conservation and Recovery Act of 1976; the Clean Air Act of 1963; and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Emmett Environmental Law & Policy Clinic at Harvard Law School, 2019). There were no permission requirements for the EPA reports used in this study. The EPA reports for hazardous materials were generated specific to the city's geographic perimeter and encompassed TRI, ICIS-AIR, SEMS, RCRAInfo Search, and Toxic Substance Control Act Search. The TRI Basic report provided information on toxic chemical releases by industrial companies (EPA, n.d.-e). The ICIS-AIR report detailed chemicals and pollutants industrial companies introduce into the air within a selected geography (EPA, 2022). The SEMS reported on the nation's cleanup of the greatest contamination and response "to environmental emergencies, oil spills and natural disasters" (EPA, 2023, para. 1).

Last, the report generated from the Toxic Substance Control Act Search provided an inventory of chemicals (unless otherwise exempted by the EPA) that were either present, manufactured, or imported into a selected geographic area (EPA, n.d.-b). These reports were generated from data provided as required by law from various reporting entities including industries, local and state jurisdictions, and governing agencies for various chemicals. These reports may be limited if industrial inventories or releases were not reported to the EPA as required. Collectively, the data from these reports for client city informed of its vulnerability to natech events.

City leaders developed the 2013 LHMP in partnership with a contract company. The plan identified the following stakeholders in the planning process: the city government, neighboring city governments, and the city's unified school district. Representatives from each group included respective members from law enforcement, fire, city legislators, city planning, risk management, emergency services, public works, and utility departments. This plan identified the city's currently recognized threats and hazards and provides a baseline for understanding its threat identification process and planning efforts for mitigation. The data provided by this 2013 plan was limited by time and may not reflect current procedures for threat and hazard identification.

The 2021 EOP was considered current within the field of emergency management provided regular reviews are being made to the plan concurrent to the plan's review schedule. The EOP was comprised of two parts with the basic plan as Part 1 and emergency operations center management and implementation as Part 2. The EOP was the guiding document for how the city will respond to emergencies and disasters toward

the lifesaving and community preserving goals for the whole community including compliance with state and federal legislation, roles and responsibilities within the city government and departments, and operational concepts for field and emergency operations center response and recovery. Like the LHMP, this plan may be limited in its currency depending on any changes made that have not been operationalized by other means. The EOP provided the framework for understanding the city's response and recovery to emergencies and disasters along with its capacity for extended coordination and response for cascading events.

Strategy for Data Analysis

As the sole researcher, I was the only person who collected and analyzed the data for the study. A research journal was maintained to record observational, theoretical, and methodological notes to support the identification of themes, provide consistency, and minimize bias. Google Drive was used for data collection and organization with a singular master folder developed to organize recording of the process steps, code identification, resources, journal observations, literature, and data. A naming convention for the file process was developed for use in Google Drive to support consistency and ease of use to accurately record the data's collection date, assigned data identification tag, and data source.

I analyzed the collected data in relation to the relevant part of the conceptual framework. Data were coded based on deductive analysis beginning with the use of coding developed from my notes derived from the literature review, that hazardous materials data applied to the natech indicator tool checklist, and city hazard mitigation

and emergency planning documents. Starting themes included vulnerability, potential natech sources, industrial accidents, natural hazards, and emergency planning. Upon completion of the analysis, the client was provided deliverables in the form of recommendations for emergency planning steps dependent on the findings of natech event vulnerability. Additionally, they were given a guidance document outlining how to repeat the natech vulnerability process in the future using the EPA reporting data and the natech event vulnerability tool from Pilone et al. (2021).

Issues of Trustworthiness

Qualitative research is determined to be trustworthy through measures of dependability, credibility, confirmability, and transferability, so there may be confidence in the study's findings. These measures support stakeholder acceptance and use of the research (Lincoln & Guba, 1985; as cited in Nowell et al., 2017). Trustworthiness also speaks to research relevance (Adler, 2022). The dependability of a study exists when a study’s process is logical, can be traced, and appropriately documented (Nowell et al., 2022). Critically important to dependability is the ability of another to replicate the steps through a detailed process of the collection and analysis of the data (Stensfors et al., 2020). Credibility, or internal validity, was achieved through data triangulation wherein the data was collected and interpreted from multiple sources and methods. Employing triangulation helps a researcher to identify gaps in patterns in the findings and can reduce systemic bias in the study (Patton, 1999, as cited in Lemon & Hayes, 2020).

The study’s confirmability was derived from the ability to demonstrate data-driven conclusions and interpretations (Nowell et al., 2022). To support confirmability,

an audit trail was developed listing the raw data, details of the data collection process (including any decisions to not use collected data), data synthesis, research methodology notes from initial and review passes, and the process of determining natech event vulnerability and whether the city's emergency preparedness plans support the vulnerability findings. Transferability supports the ability for findings to be applicable in like environments (Nassaji, 2020). Thick description, leaning heavily on the audit trial, was employed to support transferability to recreate the process in other local jurisdictions to assess for natech event vulnerability using the process and relevant hazardous materials and emergency planning data sources for that jurisdiction.

Ethical Procedures

The hazardous materials data used in this study were available for public consumption and did not require confidentiality or protection of data. The city's LHMP and EOP were also publicly available through the city's website and did not require confidentiality or protection. I maintained the data I collected within password-protected environments using Google Drive and my personal computer. The study has IRB approval number 12-01-23-0503694.

Summary

I drew from the conceptual framework presented in Section 2 to collect, organize, and synthesize data to make an assessment about the client city's vulnerability and readiness to respond to a natech event emergency at the local level. Data sourced from current EPA reports and applied to the natech event indicator tool informed the city's vulnerability to natech events. Document review of the city's LHMP and EOP informed

the current capacity to plan and respond to these events. All data were maintained on a secure Google Drive maintained by the researcher. Throughout the study, a meticulous written recording was made to document the research process to heighten trustworthiness. The following section details the research findings and recommendations for the city.

Section 4: Results and Recommendations

Introduction

The purpose of this study was to identify the natech disaster vulnerabilities within a city located in Southern California. In practice, local government departments often identify threats and hazards through a process that applies linear theory and approaches each threat or hazard as a standalone concern. Failure to identify likely and impactful secondary threats and hazards and address them in emergency planning may contribute to elevating the overall disaster risk for a jurisdiction (Krausmann and Necci, 2021). The RQs were

RQ1: What are the current sources and vulnerability levels of potential natech threats in the city based on the assessment tools in Pilone et al. (2021)?

RQ2: To what extent have identified natech threats and vulnerabilities been addressed in the city's current emergency preparedness and LHMPs?

I sought to identify potential sources of natech events within the client city using the data from the EPA reports with some of the data applied to the natech event assessment tool found in Pilone et al. (2021). The city's existing EOP and LHMPs were reviewed to assess the level of natech event threat identification and attributed vulnerability levels. The client was provided with a copy of this study, a report detailing the city's vulnerability to natech events, and a comprehensive flowchart of the process of natech event vulnerability identification including how to access relevant data sources for future use.

Data Collection

The data collected for this study included publicly available archival reports from the EPA and operational plans from the city. The city's plans were downloaded from its emergency operations website in December 2023 and uploaded to the researcher's Google Drive. At the same time, the following searches were made for the city, generated, and downloaded from the EPA's website:

- ICIS-AIR
- TRI Basic data files for 2021 and 2022
- SEMS
- RCRAInfo

All EPA-sourced generated reports were uploaded to my Google Drive file under a subfolder titled "Raw Data Files Download."

Data Analysis

Data downloaded from the EPA was reviewed over 2 months using a process of deductive data analysis. The city emergency planning documents and EPA data reports yielded information for analysis necessary to answer the RQs. The documents are described in general and in context to this study in Table 1.

Table 1

Documents, Description, and Applied Information

Document	Description	Information for study
ICIS-Air report	Summary of the locations identified as EPA-regulated stationary air polluters within the city	The report was used to identify potential sources of stationary air pollution within city borders.
TRI Basic data 2021	Information on toxic chemical releases by industrial companies in 2021	Data from this report were filtered to identify the industrial facility sources and locations of chemical releases (on-site and off-site) that violated the Clean Air Act in 2021. The data were assessed using the natech event vulnerability tool.
TRI Basic data 2022	Information on toxic chemical releases by industrial companies in 2022	Data from this report were filtered to identify the industrial facility sources and locations of chemical releases (on-site and off-site) that violated the Clean Air Act in 2022. The data were assessed using the natech event vulnerability tool.
SEMS	Information specific to hazardous waste not appropriately managed consistent with the 1980 Comprehensive Environmental Response, Compensation and Liability Act	This report was used to identify whether potential sources of natech events existed due to mismanagement of hazardous waste.
RCRAInfo	A list of facilities that handle hazardous waste within the city consistent with the Resource Conservation and Recovery Act	The source served as a reference to cross-check locations of industrial facilities identified from TRI Basic data reports from 2021 and 2022.
LHMP 2013	The city's most recent hazard mitigation plan	The plan detailed the city's definition of what constitutes a hazard and vulnerability to the city, provided a list of the city's recognized top hazards, and the context of how the city was vulnerable to these hazards.
EOP 2021	The basis for how the city plans for, responds to, and recovers from emergencies and disasters consistent with local, state, and federal requirements	The plan indicated that the city's most recent reference to hazard mitigation planning relies upon the Los Angeles County all-hazards plan and the city's hazard mitigation plan. Referenced the requirement of hazardous materials area plans.

Note. ICIS-Air = Integrated Compliance Information System for Clean Air Act Stationary Sources; EPA = U.S. Environmental Protection Agency; TRI = Toxic Release Inventory; SEMS = Superfund Enterprise Management System; RCRAInfo = Resource Conservation and Recovery Act Information; LHMP = local hazardous materials plan; EOP = emergency operations plan.

The deductive analysis began with three themes consistent with identifying vulnerabilities and risk assessments for emergency planning through the lenses of linear and network theories. These themes were hazard, vulnerability, and industrial sources. The process of directed content analysis was applied to the documents in Table 1 using the themes and codes in Table 2.

Table 2

Themes and Codes for Data Analysis

Theme	Code	Example/key quote	Reference
Hazard		"When identifying threats and hazards to include in the THIRA, communities consider two key factors: (1) the likelihood of a threat or hazard affecting the community; and (2) the challenge presented by the impacts of that threat or hazard, should it occur." (p. 13)	U.S. Department of Homeland Security (2018)
	Location	"Although incidents may have wider regional or national effects, communities completing the THIRA should focus strictly on the consequences within their community." (p. 14)	U.S. Department of Homeland Security (2018)
	Likelihood	"For the purposes of the THIRA, 'likelihood' is the chance of a given threat or hazard affecting a community. Likelihood is important to consider because communities must allocate limited resources strategically." (p.14)	U.S. Department of Homeland Security (2018)
	Impact	"To understand their risks effectively, communities should identify and select threats and hazards that have impacts that most challenge their communities, and therefore, their capabilities." (p.15)	U.S. Department of Homeland Security (2018)
Vulnerability		"Vulnerability is susceptibility to physical injury, harm, damage, or economic loss. It depends on an asset's construction, contents, and economic value of its functions. Vulnerability assessment provides the extent of injury and damages that may result from a hazard event of a given intensity in a given area." (3-1)	Federal Emergency Management Agency (2017)
Industrial sources		"The higher disruptiveness of natural events is nowadays affecting also the industrial sector, both in terms of economic losses and of cascading events, resulting in specific risks for the population and for the environment." (p. 1)	Pilone et al. (2021)

Note. THIRA = threat and hazard identification and risk assessment.

Integrated Compliance Information System for Clean Air Act Stationary Sources and Superfund Enterprise Management System Reports

ICIS-AIR report summarized the locations identified as EPA-regulated stationary air polluters within the city (EPA, n.d.-a). The search queried was for EPA data as of August 18, 2023, and provided no findings within the client's city. The SEMS report provides information specific to hazardous waste that has not been appropriately managed consistent with the Comprehensive Environmental Response, Compensation and Liability Act of 1980) (EPA, n.d.-d). The search queried for the client city yielded no findings. Additionally, no discrepant cases were identified.

Toxic Release Inventory

I then analyzed TRI Basic data from 2021 and 2022. Prior to reviewing data within the natech vulnerability tool, basic information about the data was analyzed for comparison of the percentage of toxic releases within the city compared to Los Angeles County. The city is approximately 19 square miles, which is approximately 0.4% of the county’s geographic size. In 2022, 20.17% of the 1,388 recorded toxic releases in Los Angeles County occurred within the study’s city. This was an increase from the 17.65% of the recorded 1,354 toxic releases the previous year. Despite its exceptionally small geographic footprint, the city had a fifth of the toxic chemical releases within the entire county in 2022. The TRI data files included an array of data to include the number and identification of toxic chemical releases each year, the location of these releases, and whether these occurrences were on-site or off-site. Table 3 reflects these findings.

Table 3

Chemical Releases in 2021 and 2022

Year	Total no. of toxic chemical releases	Total no. of locations with chemical releases	No. of locations with on-site releases	No. of locations with off-site releases	No. of unique toxic chemicals released
2021	239	9	8	8	55
2022	280	10	10	6	61

Natech Vulnerability Tool

The natech event vulnerability tool from Pilone et al. (2021) provided the structure to assess data from the EPA using the TRI Basic data files for 2021 and 2022. This study's applied tool was structured to identify the data source (TRI Basic data files), industrial activity, industrial classification, industrial processes that may be susceptible for natech risk, main substances, natural hazard vulnerabilities, and possible consequences (Pilone et al., 2021). The natech vulnerability tool was developed for local planner use in European countries (Pilone et al., 2021). The data applied to the tool for this study was consistent with the tool, though the nomenclature was adjusted for consistency with industrial sector terminology used in the United States. Table 4 reflects the number of chemicals released by industrial sector within the city in 2021 and 2022, all of which are vulnerable to earthquakes, floods, and windstorms per the 2013 LHMP.

Table 4

Chemical Releases by Industrial Sector

Industry sector	NAICS ID	Instances of chemicals released (no.)			
		On-site 2021	Off-site 2021	On-site 2022	Off-site 2022
Petroleum refineries	324110	96	25	130	67
Industrial gas manufacturing	325120	3	2	3	2
Other basic inorganic chemical manufacturing	325180	2	0	3	1
Plastic material and resin manufacturing	325211	1	1	1	0
Plastics packaging, film, and sheet manufacturing	326112	1	0	1	0
Bolt, nut, screw, rivet, and washer manufacturing	332722	1	1	1	1
Commercial and service industry machinery manufacturing	333310	0	0	0	0
Other chemical and allied products merchant wholesaler	424690	4	0	4	4
Petroleum bulk stations and terminals	424710	62	30	62	33
Packaging and labeling services	561910	0	0	1	0

Note. NAICS = North American Industry Classification System.

Local Hazard Mitigation Plan

The goals outlined in the city's 2013 LHMP include protecting life, the environment, and property, and supporting emergency services. To achieve these goals, planners called for the development of mitigation policies, greater collaboration with those outside the public sector, and integration of mitigation efforts with EOPs where appropriate. The plan includes the following text:

> Planning for hazards requires a thorough understanding of the various hazards facing the City and region as a whole. Additionally, it’s important

> to take an inventory of the structures and contents of various City holdings. These inventories should include the compendium of hazards facing the city, the built environment at risk, the personal property that may be damaged by hazard events and most of all, the people who live in the shadow of these hazards.

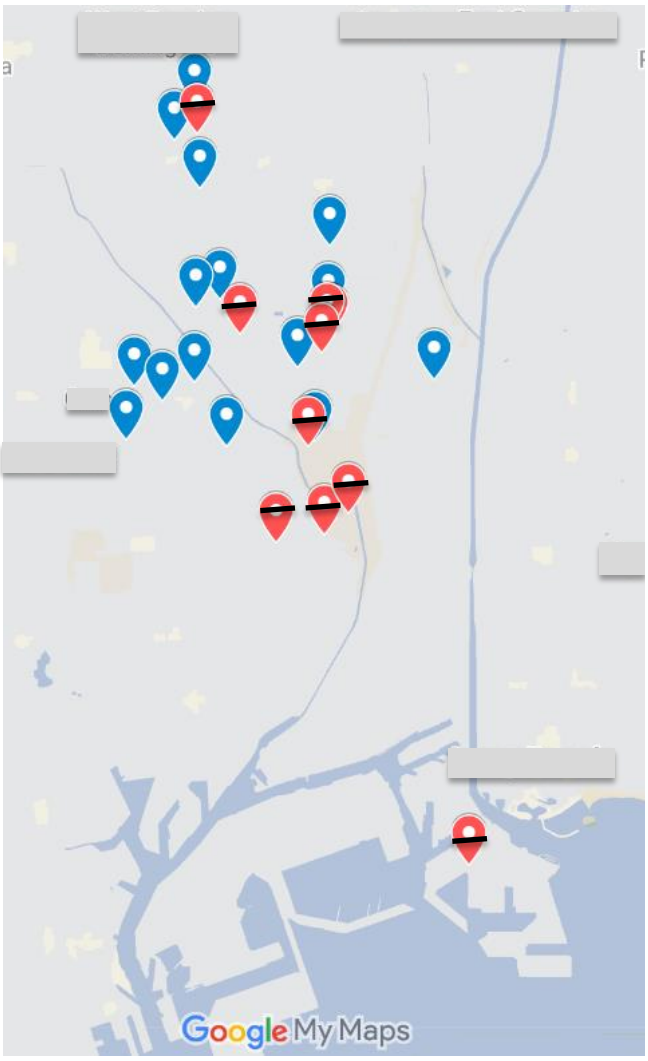
According to the plan, the three hazards of primary focus for the city were earthquakes, floods, and windstorms. These hazards were identified from many sources, internal and external to the city, including city employees and historical documents. Technological hazards, regardless of cause, were considered but not identified in the plan as a priority hazard. Though technological and hazardous facilities, including petroleum pipelines, are noted as vulnerable to earthquakes, the cascading impacts from earthquakes were identified in the form of mold, mildew, and landslides. Floods are recognized for their potential to rapidly and violently impact this highly developed city, including its pipelines, with localized urban flooding compounded by vegetative debris. Windstorms were identified to have the potential to cause destruction to commercial structures.

Within the LHMP, the city's critical and essential facilities are identified as facilities "critical to government response and recovery activities" with the county sheriff's station, fire stations, and care centers accounting for 17 locations identified by name and address as vulnerable to earthquakes and windstorms with one location also identified as vulnerable to flooding. Hazardous materials facilities were also recognized as critical if damage led to secondary impacts. I used Google My Maps to generate several maps that incorporated the 17 critical and essential locations and the locations of

on-site and/or off-site chemical releases referenced in Table 3. Figure 1 displays the critical and essential locations and the industrial locations with chemical releases in 2021 and 2022.

Figure 1

Critical and Essential Functions Relative to Chemical Releases in 2021 and 2022



Note. The critical and essential locations are blue. The industrial locations with chemical releases are red with a strikethrough line.

Emergency Operations Plan

The city's most recent EOP was codified in 2021 and leverages the county's LHMP for hazard identification and risk assessment and includes climate change, fire/industrial/hazardous materials incidents, health/biological incidents, extreme weather (in lieu of windstorms), and manufactured incidents in its list of identified hazards in addition to the already identified earthquakes and floods. The EOP also references state requirements and regulations by the state for some industries, depending on their risk threshold, to have and submit plans relevant to hazardous material emergency procedures to the county agency charged with administering the hazardous material program. Provided this information, the county agency can then develop county-wide plans for hazardous material incident response.

Findings

The city is vulnerable to natech events and critical and essential facilities necessary for emergency response may be compromised should one occur. The city's current LHMP and EOP mention the potential for secondary or cascading events after naturally occurring hazards, but do not include a risk assessment for natech events and the additional complications that may stem from the impact of these events on the resources expected to provide emergency services to the community.

Evaluation and Recommendations

The volume of industrial facilities in the city is significant with known chemical releases near critical and essential facilities. Based on the analysis of the TRI Basic data

from 2021 and 2022 through the structure of the Pilone et al. (2021) natech vulnerability tool, petroleum refineries and petroleum bulk stations and terminals may present the greatest risk for natech events. Given the large presence of industrial facilities including petroleum refineries, bulk stations, and terminals, it is recommended that the city conduct a risk assessment for natech events in its consideration of threats and hazards in it next LHMP.

Implications

The city has been presented with an identified threat to the community that could compound the harm of a naturally caused incident or disaster through chemical releases or other reactions. Natech events increase the risk to life safety and limit the ability of emergency facilities and personnel to function and respond effectively in an already challenging environment. Beyond the initial days and weeks of a given response to a natech event, the ability to recover from such an event may limit city operations, residential and commercial occupancy, and have significant implications on the local economy. Due to the city's relevance in the petroleum sector, a natech event could have a significant impact on fuel supplies and associated costs thus causing a ripple effect on the larger economy.

Deliverables and Recommendations

The client was provided with a report including data findings presented in this section which included recommendations to incorporate network theory in future threat hazard identification and risk assessments. Additionally, a guidance document on duplicating the natech event vulnerability assessment applied in this study accompanied

the report as an annex to the client report. The executive summary provided to the client can be found in Appendix A.

Recommended Solutions

Consistent with the U.S. Department of Homeland Security's (2018) guide on THIRA, this risk assessment would include private sector partners such as industrial corporation representatives with expertise in their organizations' respective risk levels and emergency procedures (2018). It is further recommended that these assessments incorporate the risk of natech events due to extreme weather beyond windstorms. Dependent on the findings of the natech event risk assessment, the city may consider mitigation efforts independent of and in partnership with industrial companies. The findings may also warrant inclusion of natech events in the LHMP thus lending to education, training, and exercising of responders and decision-makers in natech events and scenarios.

Future Natech Vulnerability Assessment

The methodology applied in this study may be duplicated by the private and non-profit sectors seeking to identify vulnerabilities to natech events for respective efforts toward mitigation efforts including developing educational and operational programs for response and recovery. Future research may include case studies on the efficacy of public private partnerships for improved mitigation efforts and preparedness planning. Cities or counties adhering to a whole community approach to understanding natech event vulnerabilities and preparing congruent to assessed risks may save lives and minimize physical and economic impacts to the community.

Evidence of Trustworthiness

The study's trustworthiness was demonstrated in its credibility, transferability, dependability, and confirmability. Credibility was evidenced in using multiple data sources to analyze the city's industrial footprint against the guiding documents for hazard mitigation and emergency operations. In support of transferability, detailed context of the data, analytical steps, and relevance to the RQs provided thick description to the study. Additionally, an audit trail was maintained as a record of the steps taken in the study from the beginning through the reporting of findings.

Data collection and analysis were documented and described in detail as evidence of the study's dependability. These steps may be duplicated by others, as noted in the deliverable to the client for future natech event vulnerability assessments. The data-driven findings from the synthesis of raw data were twice analyzed for the frequency of releases by industrial sector and through the framework of the natech vulnerability tool and hand-coded. Assessment of the industrial footprint and locations of vulnerability relative to essential city functions were mapped and analyzed for proximity providing visual confirmation of natech vulnerability. Repeated in-depth review and hand-coding of the city's most recent LHMP and EOP further confirm the study.

Strengths and Limitations of the Study

There were strengths and weaknesses to this qualitative study. The ability to assess various data from the EPA provided the researcher with greater understanding of the client city's industrial makeup. My background and experience with local hazard identification, vulnerability assessment, and risk assessment support the study's

methodology, data analysis, and findings. Further, this expertise provided insight for contextualizing the study's findings relative to gaps in the current LHMP. Secondary data analysis of publicly available data and documents made the study cost-effective.

Data collection and analysis were subject to the selection and lens of the researcher to provide greater understanding of the city's vulnerability to natech events. Additionally, natech vulnerability assessment was only a few years old at the time of the study and the applied tool was applied to improve land use planning. Analysis was subjective to the interpretation of the researcher's interpretation of bulk secondary data. Replication by another researcher may come with its own bias and findings may differ. Vulnerability assessments in future years may have additional tools or context to support the process. Engaging additional subject matter experts in the assessment process could minimize the impact of singular bias on findings with an emphasis on consensus. While the study's assessment for natech event vulnerability may be duplicated, this study's findings were limited to the client city. As the study was qualitative, no method existed to objectively verify the findings.

Summary

Publicly available data from the EPA and the client city were reviewed and analyzed to assess for natech event vulnerability within the jurisdiction and whether current city plans addressed natech events as potential threats necessitating mitigation and inclusion in EOPs. The various EPA reports provided information specific to toxic releases in 2021 and 2022 that were in violation of the Clean Air Act, the types of industries in violation, released chemicals, and the locations of where chemicals were

released. Analysis of TRI Basic data from 2021 and 2022 through the structure of the natech vulnerability tool from Pilone et al. (2021) found several industrial sectors with numerous chemical releases with petroleum refineries and petroleum bulk stations and terminals posing the greatest concern.

Analysis of the city's LHMP and EOP indicated an intent of city leadership to account for identifying hazards that pose the greatest risk to the city's residents, infrastructure, environment, and economy. Linear assessment identified earthquakes, flooding, and windstorms as the top hazards of concern. Though secondary or cascading incidents were referenced in both the LHMP and EOP, network risk assessment was not applied in the LHMP to identify potential events that could severely impact the city. Impacts on the city and its emergency response efforts were found vulnerable to natech events as the industrial footprint is very large and the areas of chemical releases are geographically adjacent to many identified critical functions for these efforts. Thus, it was recommended to the city's emergency management division to include natech events in the risk assessment process for the next LHMP. To consider these findings and aid in future natech event vulnerability identification, a detailed report was provided to the city's emergency manager.

Section 5: Dissemination Plan and Conclusion

Dissemination Plan

The findings of this study will be presented to the city's emergency manager in the form of a report which will include a copy of this study, detailed information on the process of identifying natech vulnerabilities within the city, and recommendations for future LHMPs. The client will also receive a flowchart to step through the study's natech event vulnerability identification using new data as it becomes available. The flowchart will include sample tables and links to access the EPA's relevant databases for the city's industrial data.

Conclusions

The findings of this study support the client city's ability to more thoroughly address a potential threat which extends to minimizing the impact to neighboring jurisdictions, critical infrastructure that supports fuel and transportation, the economy, and the potential for immediate and ongoing life safety and health consequences. The study's process of natech event vulnerability identification employs the use of network theory toward the threat and hazard risk assessment process which may be used in other jurisdictions which may include public-private partnerships for mitigation and emergency preparedness plans.

An improved understanding of the vulnerabilities and risks associated with natech events may foster additional education and training for first responders, private sector employees, and city planners in their individual and collaborative efforts to meet safety and future planning objectives. Like other threats and hazards, a natech event's impacts

could vary. The city could experience a small but manageable chemical release triggered by a moderate earthquake to an extreme loss of containment with the potential for explosions and toxic chemical releases into the air and waterways after a major seismic event. The residential community and those who work within the city benefit from efforts to minimize these impacts which would directly affect the environment, economy, and the city's resources including education, public safety, and land use planning. Future researchers may address natech events and the impact vulnerability and risk assessments had on a local jurisdiction's capacity to mitigate destructive impacts. Also, studies focused on the public-private partnerships toward these efforts may serve as a good contrast to findings in jurisdictions where mitigation efforts are limited to the public sector.

Summary

Natech events continue to impact the world as naturally occurring incidents trigger cascading events and at times, disasters. From earthquakes and tsunamis to intense flooding that has been exacerbated by climate change, our communities and various infrastructures are subject to threats that extend beyond what have traditionally been identified as primary threats and hazards of concern for local jurisdictions. Although efforts to advance addressing and planning for natech events has begun across Europe, not much has been completed in the United States as the time of the study.

Considering natech events for inclusion in future hazard mitigation and emergency planning efforts requires shifting the traditionally held practice of assessing for disaster risk through a linear process to one that is networked and recognizes both

cascading impacts and the high probability of constricted resources for emergency response and recovery. This qualitative study provided a process for local emergency managers and government leaders to rely on publicly available data to assess natech event vulnerability. Emergency plan and program leaders may then determine whether a risk assessment is necessary for inclusion in future LHMPs and EOPs. Where technology and industry exist, so does vulnerability to natech events. Understanding and mitigating the risks of natech events is crucial at all levels of government and in partnership with those responsible for industrial plants, technological equipment, and hazardous substances.

References

Adler, R. H. (2022). Trustworthiness in qualitative research. *Journal of Human Lactation*, *38*(4), 598–602. https://doi.org/10.1177/08903344221116620

CalOES Governor's Office of Emergency Services. (2021). *CalOES yellow book.* https://www.caloes.ca.gov/wp-content/uploads/Legal-Affairs/Cal-OES-Yellow-Book.pdf

Cruz, A. M., Steinberg, L., & Vetere, A. A. L. (2006). Emerging issues for natech disaster risk management in Europe. *Journal of Risk Research*, 9(5), 483–501. https://doi.org/10.1080/13669870600717657

Emmett Environmental Law & Policy Clinic at Harvard Law School. (2019). A manual of citizen scientists starting or participating in data collection and environmental monitoring projects. https://clinics.law.harvard.edu/environment/files/2019/09/Citizen-Science-Manual-March-2019-_FULL-VERSION_0.pdf

Federal Emergency Management Agency. (2017). *IS-0393.B: Introduction to Hazard Mitigation: Lesson 3. Assessing Risks.* U.S. Department of Homeland Security. https://training.fema.gov/emiweb/is/is393a/is393.a-lesson3.pdf

Krausmann, E. Cruz, M., & Salzano, E. (2017). *Natech risk assessment and management Reducing the risk of natural-hazard impact on hazardous installations.* Elsevier Inc.

Krausmann, E., & Necci, A. (2021). Thinking the unthinkable: A perspective on natech risks and black swans. *Safety Science*, *139*, Article 105255.

https://doi.org/10.1016/j.ssci.2021.105255

Masters, J. (2023, January 27). *Climate change is increasing the risk of a California megaflood.* Yale Climate Connections. https://yaleclimateconnections.org/2023/01/climate-change-is-increasing-the-risk-of-a-california-megaflood/

Megheirkouni, M., & Moir, J. (2023). Simple but effective criteria: Rethinking excellent qualitative research. *The Qualitative Report*, *28*(3), 848–864. https://doi.org/10.46743/2160-3715/2023.5845

Nassaji, H. (2020). Good qualitative research. *Language Teaching Research*, *24*(4), 427–431. https://doi.org/10.1177/1362168820941288

Necci, A., & Krausmann, E. (2022). *Natech risk management – Guidance for operators of hazardous industrial sites and for national authorities* (Publication No. EUR 31122 EN, Joint Research Centre No. JRC129450). Publications Office of the European Union. https://doi.org/10.2760/666413

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods*, *16*(1). https://doi.org/10.1177/1609406917733847

Pilone, E., Casson Moreno, V., Cozzani, V., & Demichela, M. (2021). Climate change and natech events: A step towards local-scale awareness and preparedness. *Safety Science*, *139*, Article 105264. https://doi.org/10.1016/j.ssci.2021.105264

Pilone, E., Demichela, M., & Camuncoli, G. (2022). Na-tech risk: A new challenge for local planners. *Chemical Engineering Transactions*, *90*, 223–228.

https://doi.org/10.3303/CET2290038

Ricci, F., Ming Yang, Reniers, G., & Cozzani, V. (2022). The role of emergency response in risk management of cascading events caused by natech accidents. *Chemical Engineering Transactions*, *91*, 361–366. https://doi.org/10.3303/CET2291061

Santella, N., Steinberg, L. J., & Aguirra, G. A. (2011). Empirical estimation of the conditional probability of natech events within the United States. *Risk Analysis*, *31*(6), 951–968. https://doi.org/10.1111/j.1539-6924.2010.01561.x

Stenfors, T., Kajamaa, A., & Bennett, D. (2020). How to ... assess the quality of qualitative research. *The Clinical Teacher*, *17*(6), 596–599. https://doi.org/10.1111/tct.13242

U.S. Census Bureau. (2022). *Place*. https://data.census.gov/profile/

U.S. Department of Homeland Security. (2018, May). *Threat and hazard identification and risk assessment (THIRA) and stakeholder preparedness review (SPR) guide: Comprehensive preparedness guide (CPG) 201* (3rd ed.). https://www.fema.gov/sites/default/files/2020-07/threat-hazard-identification-risk-assessment-stakeholder-preparedness-review-guide.pdf

U.S. Environmental Protection Agency. (n.d.-a). *ICIS-AIR overview | US EPA*. Retrieved December 2, 2023, from https://www.epa.gov/enviro/icis-air-overview

U.S. Environmental Protection Agency. (n.d.-b). *RCRAInfo overview | US EPA*. Retrieved December 18, 2023, from https://www.epa.gov/enviro/rcrainfo-overview

U.S. Environmental Protection Agency. (n.d.-c). *SEMS Search | Envirofacts | US EPA* [Search tool]. Retrieved December 18, 2023, from https://enviro.epa.gov/envirofacts/sems/search

U.S. Environmental Protection Agency. (n.d.-d). *What is Superfund? | US EPA.* https://www.epa.gov/superfund/what-superfund

U.S. Environmental Protection Agency. (n.d.-e). *Toxics Release Inventory (TRI) Program| US EPA.* Retrieved January 6, 2024, from https://www.epa.gov/toxics-release-inventory-tri-program/tri-data-and-tools#triadvanced

U.S. Environmental Protection Agency. (2023, October 20). *TRI basic data files: Calendar Years 1987-present.* https://www.epa.gov/toxics-release-inventory-tri-program/tri-basic-data-files-calendar-years-1987-present

Yang, Y., Chen, G., & Reniers, G. (2020). Vulnerability assessment of atmospheric storage tanks to floods based on logistic regression. *Reliability Engineering & System Safety*, *196*, Article 106721. https://doi.org/10.1016/j.ress.2019.106721

Appendix A: Executive Summary

An academic study was conducted in 2023 and 2024 to assess the city's vulnerability to Natech events. These events are technological incidents, emergencies, or disasters that stem from a naturally occurring event such as an earthquake, tsunami, or flood. The Fukushima Daiichi nuclear disaster in March 2011 is a well-known example of a Natech catastrophe. While initiating events may be large, as was the case in Fukushima, a singular lightning strike may also present a jurisdiction with a challenge should it trigger a Natech event.

The study relied upon data from the Environmental Protection Agency (EPA) and information from the city's 2013 hazard mitigation plan and 2021 emergency operations plan. The researcher, a professional emergency manager in Southern California, employed her expertise in threat hazard identification and academic research to conduct a case study toward the completion of her Doctor of Public Administration program.

Academic literature was reviewed and found that progress is being made for increased knowledge and identification of Natech events across Europe, however, these events are not currently common in the landscape of the threat hazard identification and risk assessment (THIRA) process in the United States. Assessment EPA data and the city's plans led to the conclusion the city is vulnerable to Natech events, notably at petroleum refineries, bulk stations, and terminals. The city has a significant number of industrial facilities which further increases Natech event vulnerability. Some of these facilities are near locations the city has identified as critical functions for emergency

response. This report outlines the analytical process employed in the study and provides tools for future vulnerability assessments for this threat.

The researcher recommends the city conduct a risk assessment for Natech events, inclusive of engaging partners from the private sector, to assess for including these events in the next hazard mitigation plan and undertaking the necessary next steps for mitigation to protect the community and its long-term interests.