An application to geospatial technology to geographic response plans for oil spill response planning in the Western Basin of Lake Erie

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A Thesis Entitled

An Application of Geospatial Technology to Geographic Response Plans for Oil Spill Response Planning in the Western Basin of Lake Erie

By

David B. Dean

Submitted as partial fulfillment of the requirements for The Master of Arts in Geography

Advisor: Dr. Patrick Lawrence

Dr. Kevin Czajkowski

Jon Gulch, US EPA

College of Graduate Studies

The University of Toledo

December 2009
Petroleum products are crucial to the function of our society. Hydrocarbons provide the fuel, lubricants and are the raw material for many products we use in our daily lives. However, these organic chemical compounds in their many forms, when released into the environment, can cause serious environmental and economic damage. Passed as a result of the 1989 Exxon Valdez spill in Prince William Sound, Alaska, the Oil Pollution Act of 1990 mandated the development of contingency plans for response to future spills of varying magnitude. Area Contingency Plans, prepared by local Area Committees, are part of the response structure established by the OPA 90. Their function is to define the steps to be taken in the first hours
after a spill to protect resources areas that may be threatened. In the period since the establishment of the current response structure, geospatial technologies have matured into useful tools for oil spill planning and response.

Each Area Contingency Plan has protection strategies, also referred to as geographic response plans, which contain the spatial and attribute data needed in a response effort. This research examines the application of geospatial technology to the development of geospatially enabled protection strategies, also known as Geographic Response Plans (GRPs) for ecologically and economically sensitive areas in the western basin of Lake Erie, including part of the states of Ohio and Michigan. It reviews existing plans and proposes a development process for geospatially enabled protection strategies in the Western Lake Erie basin.

Geospatially enabled protection strategies take advantage of existing data and the capabilities of a GIS to develop variations of protection strategies to allow for strategic changes to plans as a result of seasonal or meteorological conditions. It also allows the analysis, display and distribution of geospatial data in a manner that meet the different needs of planners, responders and incident managers. Data distribution options are discussed, including multiple paper and electronic publication options including, but not limited to Adobe Acrobat, GEOPDF, ArcReader, Google Earth and ArcIMS to make data available in the appropriate format to all personnel who require it.
Acknowledgements

I’d like to acknowledge the members of the Western Lake Erie Area Committee for their guidance, input and willingness to accept an unknown graduate student into the group. All have been friendly, patient and understanding, answering questions and offering input valuable to making this project possible. I would particularly like to thank Herb Oertli and Jan Vorhees of the United States Coast Guard Marine Safety Unit Toledo and Jon Gulch, Federal On-Scene Coordinator at the United States Environmental Protection Agency Grosse Ile, MI for their support and willingness to answer what must have seemed at times to be an endless number of questions. I would also like to thank LCDR Keith Pelletier, Commanding Officer of USCG MSU Toledo for his support of this project and wish him well as he reports to his new assignment. There have been many others, unfortunately unnamed, from the US Coast Guard offices in Toledo and Detroit, USEPA, NOMMAD (Northwestern Ohio and Michigan Mutual Aid District), Western Lake Erie Committee and other response organizations who have offered their time, experience and opinions to this project. To all involved, I offer my heartfelt thanks.

I would also like to thank Dr. Patrick Lawrence and Dr. Kevin Czajkowski for their patience and support which has allowed this project to reach completion.
Dedication

I would like to dedicate this work to my family – particularly to Kimberly Snyder, for her love, patience and understanding with this project, which I’m sure never seemed to end. I would also like to acknowledge my children, Conor and Brianagh Dean, for the summer afternoons spent with me at the University of Toledo when they could have been home playing with friends.

Thank you all for your love, patience and understanding.
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Chapter One

Introduction

Area Contingency Plans (ACPs) and their associated Geographic Response Plans are site-specific documents designed to outline steps to be taken in response to an oil or chemical spill. They are designed to improve the speed and efficiency of a response during the critical 6 to 48 hours after an incident, whether an oil or chemical spill in water, an accidental release of hazardous chemicals from a manufacturing or storage facility or an accident involving hazardous substances transported via road or rail networks, when quick action on the part of responders can keep a small incident from becoming much larger or limit the damage caused by the incident while a broader response is initiated.

ACPs are prepared by Area Committees, which consist of representatives of federal, state and local agencies such as the United States Coast Guard (USCG), United States Environmental Protection Agency (USEPA), state Environmental Protection Agencies, state Departments of Natural Resources and other stakeholders who may be affected in the event of an oil spill. Local stakeholders may include representatives of Oil Spill
Response Organizations (OSROS), refineries or other organizations that store significant amounts of hazardous materials, local fire departments and first responders. Representatives from federal, state and local wildlife reserves that may be affected by an incident are also included on the committee. The contingency plans are created in consultation with Regional Contingency Plans (RCP) and National Contingency Plans (NCP). The associated Geographic Response Plans (GRPs), also known as protection strategies, are site-specific documents that outline the steps to be taken to protect ecologically, culturally and economically sensitive areas in the event of an oil or hazardous chemical spill at or near that location.

**Problem Statement**

GRPs (protection strategies) are the local component of the contingency planning process. As of this writing (Summer, 2009) the only versions of area contingency plan maps and associated GRPs that were available are scans of paper documents or digital files published as Adobe Acrobat .pdf documents. These files are designed to be printed and the scans of existing pages are not readily modifiable. The spatial and attribute data tables associated with the response maps (*Figure 1*) are often separate from the response maps, increasing the difficulty visualizing the relationships between attribute and spatial data. Paper based plans and their associated maps, tables and graphics can be difficult to update and can be expensive to distribute on paper. The result can be response maps and supporting data tables that may
not be kept up to date, potentially leaving response and command personnel with an incomplete picture of conditions during an incident.

Figure 1. Sample response map and tabular data from the USCG Tampa Area of Responsibility (AOR). Important protection strategy data are displayed on the map, however, no road network, water access, Environmental Sensitivity Index (ESI), index map or base map data are displayed.

Geospatial technologies permit data, maps, graphics, tables and analyses that are part of a contingency plan to be updated and published electronically as frequently as necessary. Geospatial technologies in general, and geographic information systems (GIS) in particular, have matured into useful tools to develop, update and display protection strategy data and maps. Geospatial technologies allow spatial analysis of potential threats to
resources and protection strategies to protect those resources, pre or post incident. They also facilitate the development of additional strategies based on various weather conditions and spill location scenarios. An added benefit to the use of geospatial technology in response is the relative ease displaying spatial relationships, which often are more easily understood when presented graphically rather than in tabular form (Martin, et. al., 2004).

Objective

The aim of this study is to develop and propose a methodology to systematically develop and update geospatially enabled geographic response plans, also known as protection strategies, to support the mission of the Western Lake Erie Area Committee. The flexibility of geographic information systems makes it practical for the Area Committee planners and interested agencies to develop multiple versions of a protection strategy and associated maps for sensitive areas along the Lake Erie shoreline based on, for instance, seasonal conditions or prevailing wind direction and strength. Geospatial technologies can simplify the task of maintaining and updating the protection strategy data and documents as well as making them easily available to responders and planners via digital or paper publishing and distribution methods.
Study Area

The navigable streams and US waters of the Western Lake Erie basin from the Detroit River lighthouse located at approximately 42º 00’ N, 83º 08’ West to the mouth of the Vermilion River in Erie County, Ohio including the Lake Erie islands are the responsibility of the Western Lake Erie Area Committee (Figure 2). Counties represented include Monroe County Michigan, Lucas, Wood, Ottawa, Sandusky and Erie Counties in Ohio. A study area the size of the entire western basin of Lake Erie is too large for this project. To keep this project manageable, shorelines representative of the variety of conditions found in the basin – hard, manmade shorelines in the lower reaches of the Maumee River, sensitive wetlands north of Toledo along the Michigan shore of the lake, and areas of heavy recreational and tourism use around Sandusky and Catawba Island have been selected for use to develop map layouts and a systematic approach to protection strategy planning as examples for the production of associated maps covering the western basin and possibly elsewhere in the Great Lakes.
Figure 2. Study area: the Western Lake Erie Area Committee’s Area of Responsibility - Monroe County, MI and Lucas, Wood, Ottawa, Sandusky and Erie Counties in Ohio including the US waters of the western Lake Erie basin.

Response plans must be flexible, as no two incidents occur under the same conditions. Flexibility - the ability of a system to adapt input and output to changing conditions - is a strength of geospatial technology. A goal of this project is to produce a template for the use of the technology for response planning that can be applied to data collection and analysis projects across Great Lakes Basin and beyond.
1.1 Geospatial Technology in Emergency Management

All disasters or emergencies are local by nature and occur in a geographic context of space and place (Brooks, 2008). The relationship between the event and its surroundings is important to the conduct of response activities. The primary goal of any emergency response is to minimize property damage and loss of life as a result of a natural or man-made disaster. Any kind of event requiring the attention of public safety officials is by its nature spatial. For example, in the context of this study, an accident involving a collision between two ships in the open lake has a spatial location, any response to the accident must take into account the location of the accident, amount and type of product spilled, weather conditions and the location of potentially affected resources among other considerations.

The emergency management process is generally organized into four phases: mitigation, preparedness, response and recovery (Cova, 2000). Mitigation activities are designed to reduce the probability of an event and/or the risk posed by a hazard, in this case, an oil spill. Preparedness is defined as actions taken in advance of an event that improve the effectiveness of the response in the event of an emergency. A response to an emergency involves actions taken immediately before, during and/or directly after an event occurs to minimize the impact of the event. Actions taken in the recovery phase are designed to return conditions to ‘normal’ as quickly as possible. Each emergency management phase does not exist independently of the others as
they often overlap. Cova (2000) notes that in the context of a GIS, it may be appropriate to consider preparedness and recovery as its own combined phase since geospatial tools developed in the preparedness phase are frequently used in the response to an emergency. Contingency planning for oil spills follows the same four phases and in fact, done well, integrates into emergency response planning for other hazards, both natural and man-made.

Depending on the location of the spill, local fire, police and EMS response personnel are normally the first on scene. Oil Spill Response Organizations, (aka OSROs), utility personnel, NGOs such as the Red Cross and other organizations involved in emergency response support are contacted as deemed necessary. In the event an incident is beyond the capacity of local response organizations, additional response resources from state and federal sources can be called in. This process is documented in the area plan.

Conversations with persons responsible for emergency management or preparedness activities at the county and regional level indicated that, speaking generally, emergency managers and emergency management agency staff are aware of the benefits that come from using geospatial technologies for incident planning and response. However, whether from institutional inertia, a lack of understanding of the potential benefits of using geospatial technology, or a “that’s not the way we do it around here” attitude, geospatial technologies are often relegated to the task of producing paper
maps for reference rather than being used as a tool that can assist an
emergency manager in the effective management and analysis of a dynamic
situation.

Gunes et. al. (2000, p. 137) notes that “GIS technology brings to the
user the ability to integrate, store, process and output geographic
information.” Martin et. al. (2004, p. 239) observed that “certain
relationships and operational trends are more easily conveyed in a
geographic context than in a traditional tabular format.” Both make
convincing cases for using geospatial technology as an effective tool in all
phases of the emergency management process.
Chapter Two

Literature Review

A search of available peer reviewed journals and professional publications uncovered few articles written about the development process for geospatially enabled geographic response plans. There are, however, several publications from NOAA’s Office of Response and Recovery (ORR) on spill response and cleanup techniques (NOAA, 2008, Zelo, 2007, Peterson, et. al., 2002, NOAA, 2000).

The Environmental Sensitivity Index (ESI) is a basic tool for spill response planning. The ESI is a system by which shorelines are classified based on the relative sensitivity of shoreline habitats and organisms to contact with oil. The classifications range from 1 (the designation for habitat least sensitive to contact with oil) to 10 (which designates habitat most sensitive to oil contact). The system allows for additional shoreline classes within the established ESI system, allowing for unique conditions to be documented (Jensen, 1998). The development of Environmental Sensitivity Index (ESI) maps and their use in spill planning and response has been well documented (Jensen, 1998). Jensen, et. al., (1998) gives some background on
the logic of the Environmental Sensitivity Index (ESI) and its use for oil spill contingency planning and response. The authors have been instrumental in the development of the ESI as it currently exists, both the former analog and current digital iterations. Jensen et. al (1998) describes the logic and use of the ESI and the use and database design of geospatial technologies for contingency planning. Many of the 13 ESI data layers defined by Jensen et. al. (1998) for use in the ESI are also useful for planning around locations that may not be environmentally sensitive, but should be protected for economic (popular beaches, lakes or river reaches heavily used for recreational purposes), public safety (water intakes) or practical (marinas and boat ramps necessary for response activities) reasons. Jensen et. al. (1998) also describes a river reach sensitivity index, appropriate in the western Lake Erie study area for the mouth of the Maumee River at the port of Toledo up to the head of commercial navigation and the River Raisin in Monroe, MI. The river reach sensitivity index is useful for river reaches downstream of pipeline stream crossings and highway or rail bridges that carry significant hazardous material traffic as well. The environmental sensitivity index described by Jensen et. al. (1998) is significant in that development of more sophisticated planning and response maps depends on data contained in this layer.
Figure 3. Data layers used in the development of an Environmental Sensitivity Index. (from Jensen et.al., 1998). This data along with other appropriate data layers are used for the development of protection strategy maps.

However, ESI data are only part of the data necessary for effective response planning. Planners and responders require information about the location of response assets such as marinas and boat ramps for water access and fuel for boats and other powered equipment, the location of staging areas and response equipment and resources to be protected to name a few. Many of the attributes contained in these data layers are collected by local Area Committees in the process of developing an ACP. Others, such as site-specific
booming strategies and accompanying graphic representations are developed and approved by the committee.

While not peer reviewed, many publications and reports have been prepared by the National Oceanic and Atmospheric Administration’s (NOAA) Office of Response and Restoration (part of the National Ocean Service or NOS), the United States Environmental Protection Agency (USEPA), and the United States Coast Guard (USCG) on the development and implementation of area plans and the science behind the recommendations for spill cleanup activity. NOAA’s Office of Response and Restoration, part of the National Ocean Service and located in Seattle, is typically the agency advancing research on oil spill response techniques, often in consultation with specialist research and response firms.

NOAA’s *Environmental Sensitivity Index Guidelines, Version 3.0* lays out the case for standardization of a shoreline classification system and documents the ESI classification system (Petersen, et al., 2002). A shoreline classification methodology and guidelines for compiling biological and human use resource data is outlined. ESI database design and standardized symbology for ESI, biological features and human use features are also discussed.

The case for the use of geospatial technology for oil spill planning and response is outlined in a short paper presented at the ESRI User Conference in August of 2007 by Capt. Michael Alfultis and Derrick Miller, both of the
Science Department at the US Coast Guard Academy (Alfultis and Miller, 2007). They note that various support documents, including but not limited to base maps, protection strategies, access points, sensitive economic and natural resources that are currently on paper can be represented as layers in a GIS. These representations allow users to evaluate the spatial relationships between a potential threat, the resources to be protected, assets available and the location of those assets relative to the incident. The authors describe the application of geospatial technology to oil spill planning and response as a significant step forward in making the data acquired for planning and response more easily accessible and useful in the planning process as well as in the event of an incident.

An important part of the planning and response process is determining when a cleanup operation can be considered complete. That decision is more complicated if planners or incident managers do not have data on shoreline conditions prior to an incident. Shoreline assessment, also known as SCAT – Shoreline Cleanliness Assessment Techniques (NOAA) or Teams (Environment Canada), is a necessary and important step in planning and response. Shoreline assessment allows the collection of data on existing (pre spill) shoreline conditions for inclusion in protection strategies. Assessment of shorelines before an incident allows for the identification of natural collection points, boom anchorages and potential hazards to responders among other attributes. Shorelines should be segmented as part of the assessment process.
Shoreline segmentation allows SCAT data to be related to the appropriate shoreline segment in a relational database. This process allows more rapid processing and display of shoreline conditions to incident managers, improving their situational awareness. Pre-event assessment data and shoreline segments are then included in the area contingency plan, maps and attribute data tables. Pre-incident assessment of shoreline has the added benefit of allowing response personnel to become familiar with local conditions.

The Shoreline Assessment process is crucial to both accurate contingency planning and use of appropriate spill response methods. NOAA’s Shoreline Assessment Manual (NOAA, 2000) “outlines methods for conducting shoreline assessments and incorporating the results into the decision-making process for shoreline cleanup at oil spills” (NOAA 2000). The manual outlines the steps to be taken in order for a shoreline assessment to be systematic and importantly, consistent when collecting data used by planners and incident commanders in the event of a spill. Given the lengthy border between the US and Canada, significant marine traffic along the east and west coasts of North America along with the considerable commercial shipping activity in the Great Lakes, it is not surprising that Environment Canada, the Canadian Coast Guard, the US Coast Guard and US Environmental Protection Agency share the same shoreline assessment system. This similarity in SCAT methodology and philosophy between the US
and Canada made it possible for the SCAT training course for local planning and response personnel, held in the spring of 2008 at the University of Toledo’s Lake Erie Center in Oregon, OH, to be taught primarily by representatives of Environment Canada.

It is important to recognize geospatial technologies are not the ‘be-all, end-all’ for contingency planning. They are a tool that properly applied, can offer insight into complex spatial relationships not easily visualized from tabular data. Zerger and Smith (2003) evaluated the application of GIS to support a 2002 storm surge risk management and disaster management exercise in the far north of Queensland, Australia. The results of a questionnaire and post-exercise interviews indicated the best use for a GIS in the particular scenario presented (flooding as the result of a cyclone landfall) is “to pre-model risk using the GIS and to present results as paper maps” (Zerger, 2003 p. 135). While using spatial data for pre-modeling of risk and printing maps is certainly an appropriate and necessary application of spatial technology, the fixed paper maps produced can only reflect predicted conditions or the results from models run on a set of assumptions.

Once emergency managers have been educated on the capabilities and limitations of GIS, they will be better able to use its strengths to advantage. Appropriate data sets available to managers as ArcReader projects can make querying data for location and spatial relationships more straightforward, eliminating the need to be connected to the internet or remote servers via a
Virtual Private Network (VPN) or similar connectivity. Martin, et. al. (2004) observed that the design of the Australian cyclone GIS integration exercise came from the top down, meaning design and implementation of the geographic information system was done “without considering the operational requirements of emergency management personnel in a response situation” (Martin, 2004, p. 135).

In the case of the western Lake Erie Area Committee project, data included were available from and specific to the response plan. The maps and data tables attempt to take into account the end users needs and adapt the output to that end. Rather than adapt data that is held at a headquarters site to what are perceived as the needs of the responders and managers, this project has been developed with the direct input of local planners and response personnel in an effort to make the data and output maps useful when applied in an actual response situation.

Martin, et. al. (2004) made note of an important issue for GIS project development – that of data custody. In order for a GIS to be kept updated and available when needed, appropriate data custody – what parties will be responsible for hosting, maintaining and updating the GIS data - and security agreements must be worked out to allow the authorized updating of the datasets and appropriate use of data. In the case of the western Lake Erie maps, nearly all of the base map data sets are from public sources, meaning the data can be made available to any interested agency, with few
restrictions. Datasets that may be the source of appropriate security concerns will still be available but password protected.
Chapter Three

Existing Contingency Plan Structure Overview

There is a proscribed structure to all regional and area contingency plans established by the National Contingency Plan (http://www.epa.gov/OEM/content/lawsregs/ncpover.htm). The Western Lake Erie Area Contingency Plan is the local component of the Regional and National contingency plan and as required, functions in conjunction with USCG Sectors Detroit and Cleveland. Area contingency plans “describe the strategy for a coordinated federal, state and local response to a discharge or substantial threat of discharge of oil, a release of a hazardous substance or a fire from a vessel, offshore facility, or onshore facility operating within the boundaries of the coastal and inland area of Western Lake Erie” (Western Lake Erie Area Plan, 1998, Section 1000, p 1). The Oil Pollution Act of 1990 (OPA 90) requires area committees to develop a response plan adequate to “remove a worst case discharge of oil or a hazardous substance” (WLE Area Plan, 1998, Section 1100, p 1) The OPA 90 also gives the Area Committee authority to act in the event of an oil or chemical spill.
All Area Contingency Plans share the same framework although the contents of each chapter may vary depending on the location of the plan’s area of responsibility, the worst-case discharge volume and other variables.

Each contingency plan contains the following chapters:

1000 – Introduction
2000 – Command
3000 – Operations
4000 – Planning
5000 – Logistics
6000 – Finance/Administration
7000 – Hazardous Substances Unique Information
8000 – Marine Firefighting
9000 – Area Planning Documentation

An overview of each chapter follows, those with a planning and response focus have a more detailed overview than chapters that pertain less to the planning function.

1000 – Introduction. The introduction outlines the authority of the committee to act in the event of a discharge or other release of oil or chemicals within the area of responsibility of the plan. It also defines selected terms, summarizes the purpose and objectives of the plan and establishes the geographic extent of the plan. There is an explanation of the National Response system, the function of Area Plans within the National Response System framework and the established Area Response System at the state and county level.
2000 – **Command.** This section outlines the command structure and roles and responsibilities of the responsible party and various agencies at the federal, state and local level in the event of an incident.

3000 – **Operations.** The operations section outlines the organization of the operational response effort – how the organization will achieve the cleanup and remediation goals set by the Unified Command. Major functions responsible to the Operations Chief include, but are not limited to Staging Area Management, Air Operations, Recovery and Protection, Emergency Response and Wildlife. Operations are also responsible for initial notifications up the chain of command - State and US EPA, Coast Guard, and other appropriate state and federal agencies - responsible for response and incident management.

4000 – **Planning.** A primary responsibility of Area Committees is preparedness and planning. As noted previously, ACPs are developed in conjunction with Regional and National Response Plans. The Regional and National Plans provide plan development guidance to the federal on scene coordinator, who is responsible for developing and maintaining the area plan. The Regional Response Team provides a level of review for the area plan.

A planning chief is responsible for response planning within the area of responsibility of the area committee. The Planning Section of the Incident Command System has: a Situation unit, responsible for collection of information about the status of a spill and the associated response and
remediation operations; a Resource unit, charged with tracking the status of all resources including labor, materiel, fuel, etc used in response to an incident; a Documentation Unit which is charged with maintaining accurate, timely files documenting the spill and associated response and cleanup activity; and a Demobilization Unit, responsible for a demobilizing personnel and equipment as an operation under its direction is completed. The Planning Section maintains a list of various technical specialists available to support the response and remediation activity. These specialists are called and assigned as needed. Generally, a Geographic Information Systems analyst, if one is necessary, reports to the Planning Section Chief.

An important function preformed by the planning section is compiling data on economic and ecologic resources that may be impacted by contact with oil. Data on environmentally sensitive areas and the presence of endangered or threatened species within the AOR is compiled, along with the locations of sites of cultural, economic and archaeological sensitivity. The data is compiled and represented on maps and in tabular form. Data on the location and capabilities of potential support facilities such as boat ramps and marinas is also compiled and represented on protection strategy maps.

An important facet of the Planning Section’s responsibility is the development of protection strategies for use on navigable rivers, harbors and the open lake. These strategies identify likely sources of a spill and establish strategies to deal with diverting and collecting the spilled oil at specific
locations. Much of the job of the planning section is gathering, validating and collating data supporting the response strategies. Much of this data is spatial in nature (for instance the relationship between the probable source of a spill and an appropriate collection point where recovery equipment and crews can safely collect and dispose of spilled product) and is often best communicated visually.

5000 – Logistics. The Logistics section is responsible for providing facilities, services, and material to support response personnel. Logistics personnel provide the communications infrastructure and equipment, arrange the staging areas for equipment, docks for boats involved in the response, location and transportation of response equipment and myriad other goods and services in support of the incident response effort.

6000 – Finance/Administration. The Finance/Administration Section Chief is responsible for managing the costs of a response and acting as a financial advisor to the on scene coordinators. The section handles tracking time spent on the response by responders, compensation/claims in the event the responsible party is not funding the response. Access to federal funding sources for the response is handled by the Finance Section in the event the responsible party cannot be identified or is unable to adequately fund the response. The Finance/Administration section may handle procurement of equipment and services for the response, if not handled by
Finance/Administration the procurement function is handled by the Logistics unit.

7000 - Hazardous Substances Unique Information. This section outlines the procedures to be followed in the event of the release of a hazardous substance (which may or may not be petroleum based) into the environment. These actions and precautions are in addition to policies and procedures outlined elsewhere in the Area Plan. It involves procedures to identify the substance and offers tactical response options. Contacts for assistance with hazardous substance identification are given as well.

8000 - Marine Firefighting. As noted above, the actions and precautions in this section are in addition to policies and procedures outlined elsewhere in the Area Plan. This section outlines marine firefighting priorities and procedures for handling a fire aboard a vessel. Considerations involved in deciding when, where and whether to allow a burning vessel to enter port are outlined and marine firefighting resources are detailed.

9000 - Area Planning Documentation. From a response planning perspective, data found in this section has the most impact. This section has information about the Area Committee charter, organization structure, membership and required exercises. Additionally, it defines the planning assumptions from which the response strategies and protection strategies are derived. Response strategies are based on historical data on size and location of past spills. Protection strategies are based on a “response to a most
probable discharge, a maximum most probable discharge, and a worst case discharge including discharges from fire or explosion” (WLE Area Plan, 1998, p. 9000-6).

This section of the plan provides data on petroleum product facilities - name, address, contact information, water body (stream or lake) the facility may threaten in the event of a discharge, total product stored on site, the largest tank size at the facility and the products stored in those tanks, all important for planning a response strategy. Data on historical spills and discharges is included to support planning activity. The plan defines the “most probable discharge” as “the size of the average spill in the area based on the historical data available” (WLE Area Plan, 1998, p. 9000-7). The maximum most probable discharge is “the size of the discharge most likely to occur taking into account such factors as the size of the largest recorded spill, traffic flow through the area, hazard assessment, risk assessment, seasonal considerations, spill histories and operating records of facilities and vessels in the area, etc” (WLE Plan, 1998, p. 9000-7).

The plan defines the worst-case discharge for a vessel as “a discharge of its entire cargo in adverse weather conditions”. A worst-case discharge from a facility is defined in the plan as “the largest foreseeable discharge in adverse weather conditions” (WLE Plan, p. 9000-7). Note that the worst-case discharges from either a vessel or onshore facility involve adverse weather conditions. Several appendixes follow Section 9000; the most important for
the purposes of this paper is Appendix F, which contains environmental sensitivity maps and response strategy tables.
Protection strategies are designed for use by responders during the first hours of a spill when the extent of the spill may not yet be known. They are targeted at protecting sensitive resources near the source of the spill (Northwest Area Committee, Central Puget Sound Geographic Response Plan, version 2.1, 2007. p. 4-1). Samples of protection strategies developed by Area Committees around the country were reviewed in a search for best practices and standards in protection strategy mapping. Personnel involved in developing some of them were interviewed by telephone. An online search resulted in contingency plans with some geospatial components from Florida, Washington, Oregon, California and Massachusetts. Each differed in approach and cartography; while Environmental Sensitivity Atlases (ESIs) provided important environmental sensitivity data to planners in each case, the protection strategies differed in how much ESI data was included in the strategy maps provided to responders.

While there is a well-documented format and specific content requirements for area contingency plan documents (National Contingency
Plan, 40 CFR 300 described above, a national set of guidelines (or layouts) for the development of protection strategy maps and supporting tabular data are not readily available for review. This chapter offers samples of a few different approaches to protection strategy mapping used by area committees around the country along with observations on the apparent relative use of geospatial data in the maps. As the study area for this project is the western basin of Lake Erie, it is a good place to start this review.

4.1 Western Lake Erie Protection Strategies

The protection strategy maps from the Western Lake Erie (WLE) Area Contingency Plan are an example of text and paper maps from mixed sources that make up most of the protection strategy maps in the WLE area plan (Figure 4). Each strategy consists of a map and tabular data that describes the sensitive resources or areas to be protected in the event of an oil spill. The tabular data included consists of the address of and driving directions to the site, type of shoreline (no shoreline sensitivity data is included, though), a description of the resources or wildlife at risk in the event of an oil spill and guidance regarding resources to be protected first. Information regarding shoreline access and the location of an appropriate staging/recovery area are also noted, along with an inventory of resources available at the site. In most cases, there is no booming strategy noted on the maps, they are provided for reference. There often is no index map available to orient the user to the relative location of the site within the area of responsibility of the committee.
Figure 4. Existing protection strategy map and table for Maumee Bay State Park, located on Maumee Bay at the mouth of the Maumee River at the west end of Lake Erie. Note while the text of the protection strategy describes the areas to be protected, there is no notation of the protection strategies, location of water access, areas to be protected, etc. on the accompanying map.
While the information provided in the tabular data is presented in a consistent format, the sources, resolution and quality of the maps vary dramatically. Some maps in the plan are good quality scans or downloads of professionally produced maps such as those provided for Metzger Marsh and Little Portage River Wildlife Areas (Figure 5, both Ohio Division of Wildlife). The maps are legible and a reference map is provided to show the relative location of the strategy/location to be protected. However, as these maps were not produced with oil spill planning and response in mind, no protection strategy information is noted on the maps. Others are apparently copies of faxed maps with the attendant problems of pixellation and low image line resolution (Figure 6) making them difficult to read. It contains no reference map to help identify its location along the lakeshore. No protection strategy data are found on the map as the map is too small and not enough detail is present to make this map useful for a response.
Figure 5. Samples of professionally produced maps used in the Western Lake Erie Area Plan. Maps produced by the Ohio Division of Wildlife.
4.2 San Francisco Bay Environmentally Sensitive Sites map

The San Francisco Bay Environmentally Sensitive Sites maps use the same layout as those for the rest of the California coast, so they can be examined as examples of the California Office of Spill Prevention and Response’s (OSPR) approach to sensitive site mapping. While the maps supporting the Western Lake Erie Area Plan appear to have been sourced from wherever they could be found, those included in California’s San Francisco Bay plan, and the rest of the state, use parts of USGS 7.5’ quads as base maps. Each site strategy contains a consistent layout for tabular data and maps. Each site summary has a site summary header that includes the strategy number, Thomas Guide locations (spiral bound maps widely
available on the west coast but not generally available elsewhere with the exception of large metro areas), USGS Quad name, NOAA chart number, site latitude/longitude and date last modified.
Figure 7. Sample of the California Office of Spill Response (OSPR) protection strategy pages containing a wealth of information but other than the booming strategies, there is no geospatial reference to the protection strategy site or any other information on water and land access to the site. The location of the staging area relative to the protection strategy site is also not represented in these maps.
Each site document has sections for site description, seasonal and special resource concerns, resources of primary concern, cultural historical and archaeological sensitivities, key contacts data, a space for additional site summary contents, concerns and advice to responders and hazards to and restrictions for responders. A separate response strategy section outlines each numbered response strategy (note that there can be multiple strategies on one map) and a detailed explanation of how to execute the objective of each strategy. A table of resources required, such as boom, skimmers, boats, vacuum trucks, labor to deploy and tend booms and skimmers, for each strategy is also included.

Logistics are covered by sections including directions to the site, any available land access (some sites may not be accessible from the land side), water logistics, including access limitations due to water depth and obstructions, and the availability of launching, loading, docking and service facilities near the site. The last printed section outlines the location of appropriate facilities, staging areas, possible field posts and equipment available. This section may also note contact names or organizations that can help locate appropriate sites for response activities. Note that in each case, if there is no information for a particular heading, the area below it is left blank.

The last page of each site strategy is a map of the area described by the site strategy, with each strategy overlaid. Type of boom to be deployed, boom
configuration, boom anchor or stake locations, skimmer positions and locations of oil exclusion dikes are noted on the maps. Interestingly, no small-scale index or reference map noting the location of the response map is given, nor is a map of the local area provided. Also missing is any notation on the map of species at risk, economic resources at risk or general shoreline sensitivity information provided by ESI data. This data may be available elsewhere as part of the area plan. The web site from which the strategy was acquired had no references to additional data. While much of the information provided on an ESI map is included in the tabular data, its inclusion on a response map may make the situation and relative locations of the threat and resources to be protected clearer to those responders not intimately familiar with the area. Shorelines are a dynamic system, the use of USGS 7.5 minute quads as base maps may be an issue as they are typically out of date and will no longer be updated (http://topomaps.usgs.gov/).

4.3 Buzzards Bay MA Geographic Response Plan

The Buzzards Bay Geographic Response plan, in its current form, was developed as a result of the April 2003 Bouchard B-120 spill of approximately 96,000 gallons of No. 6 fuel oil into the waters of Buzzards Bay. The spill eventually oiled more than 90 miles of shoreline and killed in excess of 500 birds (NOAA Damage Assessment Remediation and Restoration Program, http://www.darrp.noaa.gov/northeast/buzzard/index.html). The format of the Buzzards Bay GRP is somewhat different than some of the others evaluated.
The Buzzards Bay GRP consists of a series of protection strategies along the shoreline of the south coast of Massachusetts between Cape Cod and the state of Rhode Island (Figure 8). Each protection strategy, referred to in the document as a GRP, consists of a GRP tactics map, which provides an overview of the strategy and a deployment diagram. A tactics table provides a description of the location of the strategy, resources to be protected, staging areas, site access, available resources to execute the strategy and site-specific special considerations of which response crews should be aware. Site photos, which may be oblique aerials or pictures of the area taken from the ground follow, along with a table containing local emergency contact numbers. The Buzzards Bay plan has a large index map available online showing the overall location of the bay and relative location of each strategy (Figure 8).
While apparently adequate for the task at hand, the Buzzards Bay GRPs take a different approach than the California OSPR or Northwest Area Committee’s strategies have done. The strategies, which were compiled by Nuka Research to replace representations created by Research Planning, Inc., contain no small scale reference maps or other graphic elements to
assist responders in locating themselves and do not appear to take advantage of geospatial technology to make data available to responders.

A GIS was used to develop the paper maps for the Buzzards Bay GRPs but they do not appear to take advantage of the potential benefits offered by using the data collected when compiling the maps for analysis during a response. However, since the data and shapefiles for the GRPs are provided to the Commonwealth of Massachusetts by Nuka Research (Elise DeCola, Nuka Research, personal communication), it would be possible for the data to be used for analysis.
Geographic Response Plan for Buzzards Bay, Massachusetts

Wareham River System, BB-23

Figure 9. Wareham River System protection strategy from the Buzzards Bay MA Geographic Response Plan.
### Geographic Response Plan for Buzzards Bay, Massachusetts

<table>
<thead>
<tr>
<th>ID</th>
<th>Location &amp; Description</th>
<th>Response Strategy</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB-23-01</td>
<td>Wareham River System</td>
<td>Direct and Collect - Shoreside</td>
<td>Deploy anchors and boom with skiffs. For a) place 1100 ft of 18&quot; boom from Swifts Neck in S/E direction to red can &quot;16&quot;. For b) place 800 ft of 18&quot; boom from point on eastern shore in a NW direction to given can &quot;15&quot; to create an open channel. Set up shore-side recovery unit at Swifts Neck and passive recovery on eastern shore. Place anchors every 200 ft. Tend throughout the tide.</td>
</tr>
<tr>
<td>BB-23-02</td>
<td>Wareham River System</td>
<td>Exclusion</td>
<td>Boom can be deployed by skiff and from shore. For a) set 1000 ft of 18&quot; boom between locations shown in diagram. Use anchor stakes on shore. For b) set 500 ft of 18&quot; boom between locations shown in diagram. Use anchor stakes and one anchor set.</td>
</tr>
<tr>
<td>BB-23-04</td>
<td>Wareham River System</td>
<td>Direct and Collect - Shoreside</td>
<td>Deploy anchors and boom with skiffs. For each site place 6x200 ft sections of 18&quot; boom in a cascaded fashion to divert incoming oil to the collection sites. Set up shore-side recovery and place passive recovery at collection points. Tend throughout the tide. Note: By setting a) and b) Marks Cove should be protected in the predominantly S/W while. Alternative strategy to a) and b) is to extend a) to the Corner Point shorefence.</td>
</tr>
<tr>
<td>BB-23-05</td>
<td>Wareham River System</td>
<td>Beach Burns</td>
<td>Build beach berms approximately 90 ft long. Use local beach and fast tidal bar sediments. If the berms are expected to remain in place for more than a few days, place a 20 x 12&quot; pipe in each channel and build the berms on top of the pipe. Use a culvert plug to control water flow through the pipe.</td>
</tr>
<tr>
<td>BB-23-06</td>
<td>Wareham River System</td>
<td>Passive Recovery</td>
<td>Place nass or sorbent boom along marsh front to minimize damage and facilitate recovery. Replace as necessary to maintain the recovery.</td>
</tr>
<tr>
<td>BB-23-07</td>
<td>Wareham River System</td>
<td>Free oil Recovery</td>
<td>Deploy free oil recovery strike teams upwind and up current of the Harbor. Use aerial surveillance to locate incoming slicks.</td>
</tr>
</tbody>
</table>

*November 28, 2008*
## Wareham River System, BB-23

<table>
<thead>
<tr>
<th>ID</th>
<th>Response Resources</th>
<th>Staging Area Site Access</th>
<th>Resources Protected</th>
<th>Special Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB-23-01</td>
<td>First Responder</td>
<td>Staging Area: Rt. 25 exit 1, Wareham Park and Ride. Site Access: Rt 6 to Swifts Beach Rd. Chart 1323-1</td>
<td>Fish, shellfish, fishes. Birds, waterfowl, concentration, Firing Flies. Marsh plants, tides, barrier beach, outer grass beds, sand beaches.</td>
<td>Vessel must have local knowledge. Currents can exceed 2 knots in main channel.</td>
</tr>
<tr>
<td>BB-23-01</td>
<td>First Responder</td>
<td>Staging Area: Rt. 25 exit 1, Wareham Park and Ride. Site Access: a) Rt 6 to Swifts Beach Rd to Libra Ave to Askens Ave b) Rt 6 to Indian Neck Rd to Putnam Dr Chart 1323-1</td>
<td>Same as BB-23-01.</td>
<td>Same as BB-23-01.</td>
</tr>
<tr>
<td>BB-23-01</td>
<td>Unified Command</td>
<td>Staging Area: Rt 25 exit 1, Wareham Park and Ride. Site Access: a) Rt 6 to Swifts Beach Rd b) Rt 6 to Indian Neck Rd to Long Beach Rd.</td>
<td>Fish, shellfish, fishes. Birds, waterfowl, concentration. Habitat - marshes, outer grass beds, sand beaches.</td>
<td>Vessel must have local knowledge. Minimum current expected. Most vessels may need to be moved.</td>
</tr>
<tr>
<td>BB-23-01</td>
<td>First Responder</td>
<td>Staging Area: Same as BB-23-01. Site Access: a) Rt 6 to Swifts Beach Rd b) Rt 6 to Indian Neck Rd to Ingemason Dr c) Rt 6 to Indian Neck Rd to Long Beach Rd Chart 1323-1</td>
<td>Birds, waterfowl, concentration. Habitat - marshes, outer grass beds, sand beaches.</td>
<td>Coordinate with DEP. If areas are to remain in place for more than a few days, construct underflow data. Monitor for incoming oil. Emergency permit from DEP required.</td>
</tr>
<tr>
<td>BB-23-04</td>
<td>First Responder</td>
<td>To be determined at time of incident. Same as BB-23-01.</td>
<td>Same as BB-23-01.</td>
<td>Use same boom for persistent oils and sorbent booms for non-persistent oils.</td>
</tr>
<tr>
<td>BB-23-05</td>
<td>Unified Command</td>
<td>Deploy multiple boom recovery skimmers as required to maintain interception of oil before it impacts sensitive areas. Vessel Platform Via marine water. Chart 1323-1</td>
<td>Same as BB-23-01.</td>
<td>Vessel must have local knowledge.</td>
</tr>
</tbody>
</table>
Wareham River System, BB-23

Middle of Wareham River System looking northeast at low tide on 29 May 2004. RPI photo

Swifts Beach on 31 May 2004. View looks east at mid tide. RPI photo

View of northern shore of Wareham River system on 29 May 2004. RPI photo

Local Contact Numbers:
Chief Robert McDufty, Wareham Fire Department............(508) 295-2972
Chief Howard Anderson, Onset Fire Department...........(508) 295-2122
Mike Purolo, Wareham Harbor Master.....................(508) 291-3100 x 3185
Massachusetts Dept. of Fish and Wildlife...................(508) 792-7270
The Coalition for Buzzards Bay.................................(508) 999-6363
4.4 Northwest Area Committee, Snohomish River & Central Puget Sound Protection Strategies

The Northwest Area Committee developed their Puget Sound protection strategy maps and data in collaboration with Golder Associates. Puget Sound has approximately 2500 miles of shoreline, too large to effectively produce one protection strategy map set. As a result, it was broken down into eight GRPs – (from north to south) North Puget Sound, San Juan Islands, North Central Puget Sound, Admiralty Inlet, Central Puget Sound, Hood Canal, South Puget Sound and Nisqually River. Each of the Puget Sound GRPs is similar in layout, content and data presentation.

The Central Puget Sound strategy, which will be used as an example of the Puget Sound response plans, consists of 11” x 17” maps with protection strategy locations and boat launch / water access locations noted. An 11” x 17” potential spill origins map follows; each potential spill location has protection strategy tables listing protection strategies associated with that particular potential spill location. Each of these regions is broken down into smaller areas (Figure 10) with the potential spill locations and protection strategies represented. Protection strategies for each potential spill location are contained in tables preceding the protection strategies (Figure 11). Each protection strategy and potential spill location is referenced by a callout containing the protection strategy or potential spill location reference number.
and a general graphic representation of the boom configuration for the protection strategy at that location (Figure 10).

The actual response strategy for each location is found in a set of tables following the maps. These tables contain data fields describing the strategy number, status of the strategy, a location given as the water body name, its lat/lon coordinates and the page number where the map is found, the response objective, the amount of boom required to execute the objective, general instructions describing how to achieve the response objective and an internet link to oblique shoreline images kept by the Washington Department of Ecology (Figure 12, found at http://apps.ecy.wa.gov/shorephotos/scripts/bigphoto.asp?id=KIT0634 and http://apps.ecy.wa.gov/shorephotos/scripts/bigphoto.asp?id=KIT0635) and resources targeted for protection. The Puget Sound protection strategies do not contain maps or graphic representations of the protection strategies; determination of how to execute the strategy is left to the response crews.
Figure 10. Northwest Area Committee, Central Puget Sound Proposed Booming Strategies Index Map. This and the following images, maps and tables were used as components of the proposed Western Lake Erie booming strategy maps.
4.5 Proposed Booming and Collection Strategies - Matrices

Table 4-21: Proposed Booming Strategies and Resources Targeted (Cont)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Current Status</th>
<th>Location (NAD83 HARN)</th>
<th>Response Objective</th>
<th>Feet of Boom</th>
<th>Strategy Implementation</th>
<th>Shoreline Oblique Photo</th>
<th>Resources Targeted</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPS-21</td>
<td>Visited and Not Tested 05/01/2006</td>
<td>Lagoon near Clear Creek N 47° 38.847' W 122° 41.021'</td>
<td>Exclusion - Prevent oil from entering lagoon.</td>
<td>100ft Contractor Boom</td>
<td>Close oil small lagoon to SE of Clear Creek.</td>
<td><a href="http://apps.ecy.wa.gov/shoreplhoto?script=bigphoto.asp?id=KIT075">http://apps.ecy.wa.gov/shoreplhoto?script=bigphoto.asp?id=KIT075</a></td>
<td>sensitive habitat, waterfowl</td>
</tr>
<tr>
<td>CPS-23</td>
<td>Visited and Not Tested 05/01/2006</td>
<td>Fletcher Bay N 47° 38.609' W 122° 34.909'</td>
<td>Exclusion - Keep oil out of Fletcher Bay</td>
<td>600ft Contractor Boom</td>
<td>Deploy boom in a chevron configuration across the entrance to the bay.</td>
<td><a href="http://apps.ecy.wa.gov/shoreplhoto?script=bigphoto.asp?id=KIT0578">http://apps.ecy.wa.gov/shoreplhoto?script=bigphoto.asp?id=KIT0578</a></td>
<td>sensitive habitat, salmonoids (ecdthodios)</td>
</tr>
</tbody>
</table>

Figure 11. Table containing tabular data (boxed in red) for booming strategy CPS 24 (circled in red on Figure 10). The links in the second column from the right refer to oblique aerial images of the location referenced in the strategy (below) which are hosted by the Washington Department of Ecology.

Figure 12. Oblique aerial images to supplement the tabular data in Central Puget Sound booming strategy CPS-24 above.
The Snohomish River GRP protection strategy is designed for response to spills in a river. However, the approach used for developing the pages is appropriate and can be used to develop data sheets for both lacustrine and riverine environments. Each protection strategy contains an aerial photograph of the area, its location, the booming objective and its proposed implementation, staging locations and resource requirements for implementation of the protection strategy (Figure 13). A graphic representation of the booming strategy is overlaid on an aerial photograph for reference; images of the site from the ground are also included. Where appropriate and available, graphs for monthly average flow and average (current) velocity vs. flow are also included although the data may not be available for all locations. Driving directions and a map are provided as part of the layout although it is not always clear where the starting point for the directions is (Figures 13 & 14).
Figure 13. Page one (of two) of a sample inland response plan for the Snohomish River, Washington. Data and page layouts from the Central Puget Sound marine GRP and the Inland GRP can be combined to create a template for both shoreline in the open lake and rivers to the head of navigation.
Figure 14. Second page of the sample Snohomish River response plan. This page provides additional pictures of the site along with driving directions or other access instructions if the site is not accessible by vehicle. In addition river flow and velocity data is included where applicable or available.
4.5 Tampa, FL Area Contingency Plan

The Florida Fish and Wildlife Conservation Commission (FWCC) produced detailed ESI maps for the coast of Florida. NOAA produced protection strategy maps and data tables and the US Coast Guard edited them. The protection strategy for a particular area consists of an 8 ½” x 11” grayscale map of the area with standardized notation for booming strategies, protection priorities, numbered protection strategies, along with the presence and location of sensitive species (Figure 15). Numbered tables containing data referring to protection strategies noted on the map follow the map sheet. The tables contain data for responders including latitude and longitude of the area to be protected, shoreline habitat, wildlife or resources to be protected, presence of endangered species and information about seasonal presence or absence of species. In addition, protection strategies, including type and quantity of boom required, potential collection points for oil, methods of access to location (vehicular, helicopter, boat, aircraft are the variables used on these tables) along with directions to access points and resources that may be available to responders are provided. However, the maps do not contain any road networks, requiring separate maps to allow crews unfamiliar with the area to find boat ramps, staging areas, backshore access locations, etc. noted on the maps. ESI data are also not represented on the Tampa maps. However, the boom priorities and locations along with the assets to be protected are fairly clearly marked. In all, the Tampa protection strategy
maps available for review did not appear to take advantage of geospatial technology for either compilation or distribution.

Figure 15. A sample response map from the Tampa AOR and one page (of nine that refer to locations on the map) of protection strategies. The tabular data contains significant detail regarding each protection strategy but the maps do not support the strategy as well. The Tampa Bay protection strategies do not take advantage of geospatial technology.
4.6 Jacksonville, FL Protection Strategies

The U.S. Coast Guard and Florida Fish and Wildlife Conservation Commission Research Institute collaborated on the development of protection strategies and maps for the east coast of Florida, along with the Georgia shoreline and limited sections of South Carolina coastline in the vicinity of Charleston. The protection strategy maps are based on environmental sensitivity data and maps compiled by Research Planning, Inc. The US Coast Guard developed the protection strategies. This particular protection strategy design uses the ESI data in base maps and adds icons (diamonds) for each strategy located on the map. The diamond icons - 1, 2 or 3 diamonds based on response priority (more diamonds are higher priority) – (Figure 16) are labeled with, and in PDF form linked to, a site ID related to an “Oil Spill Sensitive Area Report” (Figure 17). This document outlines the information required to execute the protection strategy including, but not limited to:

- Latitude & Longitude (DMS & DD)
- Site Name
- Stakeholders/Contact info
- Habitat/Wildlife/Resources to be protected and any threatened or endangered species that may be present
- Staging areas/collection points/protection strategy and resources required
This response map and data set (Figures 16 & 17) is one of many compiled into an atlas for the US Coast Guard Sector Jacksonville covering the St. Johns River and northeastern coast of Florida. The coastline and river shore were divided into 2.5 minute tiles and the tiles compiled into a .pdf index map. This plan uses the navigation functionality found in Adobe Acrobat to good effect. The index map tiles are linked to the appropriate response plan map and data. Each response plan map includes an index map (Figure 17). The tiles on the index map are linked to the appropriate area response plan map similar to the index map. Each protection strategy icon (diamonds) on the response map is linked to the page containing data on the strategy. Links to the peripheral strategies in each direction (if there is one) are found along the boundaries of the response plan map. This navigation convention simplifies navigation to specific tiles either from an index map or between adjacent tiles. This functionality is recommended for projects saved as Adobe Acrobat .pdf files. It allows users who need to navigate from one strategy to another, whether or not the strategies are adjacent, to do so with a minimum of searching.
Figure 16: Index map and legend for the US Coast Guard Sector Jacksonville ESI Map set. The numbered boxes on the index map link to the appropriate protection strategy. In this case, strategy EFL-26 is used as an example.
Figure 17. ESI map and response strategy EFL-26 from the USCG Sector Jacksonville (JAX) GRP. Linked from the index map in figure 11, this map contains links to five protection strategies, noted by the diamonds (X on this map due to an Adobe Acrobat import error).
4.7 Using Google Earth for Response Mapping

In addition to strategy documents published as Adobe Acrobat .pdf files, the US Coast Guard Sector Jacksonville, FL in cooperation with the Florida Department of Fish and Game have created Google Earth .kmz files of many of the data sets contained in the geographic response plan maps for the sector. A sample of some of the data layers displayed in Google Earth is shown in Figures 18 and 19. Unfortunately, only the response plan index maps are available to the public; the .pdf versions of the GRP maps are not currently available for comparison to the Google Earth data. While Google Earth is useful for a quick overview of the data, there are some drawbacks to its use. Whether the drawbacks are significant depends on the application of the data.

From a cartographic representation perspective, as of this writing (Summer 2009), using Google Earth 5.0 beta, there seems to be no mechanism to display map scale, either verbal or a scale bar, there also appears to be no legend as such, where the representation for layers is displayed. The “Places” table of contents window can quickly become unusable as a legend when the number of layers increases. It is not possible to insert an index map for reference (at least in the free version of Google Earth), forcing the user to zoom in and out to get a sense of spatial relationships at large and small scales. It is also difficult to modify
annotation, which can make map difficult to read at some scales as when labels from multiple layers are stacked on top of one another.

Figure 18. Screen capture from Google Earth with bathymetry data for response plan map EFL-26, located on the Indian and Banana Rivers just west of Cape Canaveral, FL. Compare detail in protection strategy map EFL-26 (Figure 17) with detail in the aerial image of the same area used by Google Earth.
Figure 19. A zoom of the lower left corner of Figure 18 shows more detail of bathymetry and booming strategies for EFL-26 from the USCG Sector Jacksonville, FL Area Contingency Plan.

Another potential issue of which to be aware is the potential variation in spatial resolution, date (year) and season of capture of imagery found in Google Earth. Google Earth uses a mosaic of satellite and aerial imagery captured at varying spatial resolutions, from different years and at different times of the year. It is possible the imagery available for the desired location may not be available at a suitable spatial resolution, the image may be out of date (not current) or the image may have been captured during a season that makes the imagery unsuitable for planning and response purposes. Figure 20 illustrates a typical Google Earth image covering part of the WLE area of
responsibility as of July, 2009. Seasons in the window vary significantly. The left part of the image is a winter image (reported as Feb. 13, 2005); the land portion of the right side of the image is reported as June 17, 2006. The tan and blue portions of the image have no image date reported, the upper right portion of the window is reported as having been captured July 16, 2003.

While the use of Google Earth can make data easily viewable, in its present configuration the free version of Google Earth has drawbacks that can make it less than ideal for spill planning and response use. However, in locations where high resolution imagery is available, details visible in that imagery but not elsewhere may be useful to decision makers. An internet connection is required to use Google Earth and notebook computers with cell phone “air cards” allow connection to the internet through cell phone carriers where service is available. Data rates may be limited, potentially making the utility of a connection less than optimal.

A workable solution for members of the Incident Command System with a need to manipulate data is the use of an Arc Map project published as an Arc Reader document. This file can be configured to be password protected, or restricted access data layers within the file can be protected by a password or by having them hosted remotely on a server. Access to restricted data would be available for personnel with a cellular “air card” and appropriate rights to the server hosting the data. This option may be less reliable and slower than local access to files. However, it is possible to design
an ArcReader project so the files that must be accessed in this manner are small enough to make this option viable.

Figure 20. Sample from Google Earth of an area including and just east of Toledo, OH (and within the Western Lake Erie Committee AOR) displaying multiple spatial resolution imagery.
Environmental Sensitivity Index (ESI) maps and tables are the basis for protection strategy development. The data included in the ESI maps provides much of the information supporting protection priority decisions made by planners and responders. Shoreline classifications, Biological Resource and Human Use Resource data are also represented on ESI maps. ESI maps, designed to support planning activities, seem to be widely available, regional and site specific GRPs or protection strategies less so. The concept of classifying environmental or shoreline sensitivity to oil was first applied in advance of an oil slick from the 1979 blowout of the IXTOC I experimental platform in the Gulf of Mexico (Jensen, et al, 1998). Since then, the ESI has evolved to become a standard data set used for oil spill contingency planning and response.

US Geological Survey (USGS) 1:24,000 scale 7.5 minute quads have long been the standard for base maps. As orthorectified satellite or aerial images of appropriate spatial resolution have become more readily available and affordable, they often supplement or replace the USGS quads as a base
layer. The USGS 7.5 minute quads are likely to be out of date as a result of a long update interval. Along the Great Lakes, as elsewhere, shorelines change quickly as a result of natural morphologic processes and rapid economic development, rendering the USGS quads less than useful for planning purposes. The recent development and subsequent availability of a broad range of data sets covering transportation, natural resources and economic data to name a few and regularly updated aerial imagery covering large areas at scales down to 1”= 200’ can provide better spatial resolution and more current data to planners and responders.

Geospatial technologies have progressed significantly since the most recent version of the western Lake Erie protection strategy maps were compiled in 1998. At the time, given the cost of GIS software and hardware along with a relative lack of geospatial data, the traditional method of marked up copies of available paper maps was the best available technology given the cost of compiling and drawing new protection strategy maps that would become out of date relatively quickly.

Currently, the tabular data and protection strategies compiled for the protected area are presented as a sheet attached to the map (Figure 21). Data included in the protection strategy are protected area address, contact name and telephone number, directions to administrative offices, type of shoreline or habitat to be protected, the kind of wildlife or resources at risk, booming priorities, water/shoreline access points, staging and recovery area(s),
available local resources (booms, labor, vehicles, boats, ramps, etc), and additional “significant” information. Because it is contained in a text based file, this information is fairly easy to update regularly.

Figure 21: Sample of existing Environmental Sensitivity/Protection Strategy maps from the 1998 edition of the Western Lake Erie Area Plan. While the protection strategy text is understandable, the low line resolution and hand notation makes the booming strategies and location of water access and staging difficult to interpret even if familiar with the area.

Maps associated with the protection strategies appear to have been acquired from various sources and are of varying dates, quality and line resolutions. Several maps have proposed booming strategies or other potentially important notation marked on them, but most do not. The variation in quality, sources dates and resolution of the existing maps along
with the difficulty of updating and republishing the maps help make the case for the development of geospatially enabled protection strategies.

5.1 Federal Geographic Data Committee Data Themes.

The Federal Geographic Data Committee (FGDC) identifies seven “themes” of spatial data it considers the basis for the development of widely available spatial data layers (http://www.fgdc.gov/framework/frameworkoverview). Data layers contained in these themes provide base layers upon which the response map data layers are stacked. Not all of these themes will necessarily be used simultaneously but all are important as base data layers to support planning and response efforts. These themes are (in no particular order):

- Geodetic Control
- Cadastral
- Orthoimagery
- Elevation
- Hydrography
- Administrative units
- Transportation

Planners and incident managers are the experts on what data are required when and by whom, particularly early in a response. They should be
consulted to help group data layers so the data required is easily accessible to planners.

The data themes listed above provide a framework of base data upon which planning and response datasets can be displayed. Base layers used in this project are (following the FGDC Framework) are:

• **Orthoimagery**: sourced from the Ohio Statewide Imagery Program (OSIP) for Lucas, Wood, Ottawa, Sandusky and Erie Counties in Ohio and National Agricultural Imagery Program (NAIP) imagery for Monroe County, MI. The spatial resolution of the OSIP imagery is one foot per pixel, the NAIP imagery is one meter per pixel. Both spatial resolutions are useful for evaluating spatial relationships between features on the imagery and related data contained in data layers.

• **Administrative Units**: Boundaries of various administrative units are included in both filled polygon form, located in layers below orthoimagery, and outline form, used in layers displayed above orthoimagery. Administrative unit layers include regional, state, county, township and municipal boundaries.

• **Hydrography**: For the purposes of this project, hydrography is generally a reference layer, as most oil spill response planning is for locations along the lowest reaches of navigable rivers and the open lake. A logical extension of this project is to use the intersections of hydrographic line features and transportation (roads or rail lines) or
pipelines to identify potential locations of spills into streams. The February 18, 2009 spill of approximately 30,000 gallons of crude oil into Rocky Ford Creek and the Portage River in Wood County, OH (Bowling Green Sentinel Tribune, 2009) reinforces the importance of locating such intersections and planning for a potential spill into waterways.

• **Transportation:** Transportation data layers included in this project are highway layers, separated into an all roads layer for use when zoomed in to large scales and a major highways layer, defined as State, Federal and Interstate highways, useful when the data are displayed at smaller scales. Active railways are also included, as well as a pipeline route layer. A shipping routes layer for the entire lake is available should it be identified as useful by planners.

• **Elevation (and bathymetry):** Elevation and bathymetry data in this particular application are not terribly important. The data are available from the State of Ohio and NOAA and may be useful in the future if, for instance, surface flow modeling were to be done.

• **Cadastral:** Cadastral data may be useful to provide parcel ownership and contact information in the event of a spill. This data may be important during weather related incidents but, with the exception of gaining permission to access the shoreline, the layer may not be significant for spill response. When deemed necessary or useful, the data may be available from county auditors.
5.2 ESI data layers

Peterson et.al. (2002) describes a data grouping structure for ESI maps that provide data that is potentially useful down to the protection strategy/response plan level:

**Shoreline classification:** Includes ESI sensitivity classification, persistence of oil on or in the shoreline and ease of cleanup.

**Biological resources:** Includes the presence or absence of sensitive aquatic and terrestrial plants, animals, birds, amphibians, invertebrates, etc along with fish. An important element that must be included is the temporal (seasonal) presence of sensitive species. The western basin of Lake Erie lies along a major flyway for migrating birds which use the Lake Erie Islands as stepping stones as they cross the lake. Many migratory species remain along the Lake Erie shore only part of the year, some visit only briefly as they pass through the area on their way to and from nesting areas. Their seasonal presence or absence should be noted in attribute data accessible by planners.

**Human-use resources:** Defined as points, lines or polygons such as beaches, parks, water intakes, marinas/boat ramps, archaeological areas etc which may have a particular sensitivity to oil. The sensitivity may be economic and/or ecological, as in the case of marinas and popular beaches or tourist areas or it may affect public health as in the
case of public water supply intakes. The municipalities served by water intakes located in the open lake typically do not have an alternate source of water, making them particularly sensitive to oil or other chemical contamination.

**SCAT data layers:** The Shoreline Cleanup Assessment Techniques (SCAT) forms generate a significant quantity of data, including but not limited to shoreline segments, presence or absence of oil, and oil coverage if present. These layers are related to other data layers used in the protection strategy maps by a shoreline segment layer, which has yet to be developed. Prior to an incident, SCAT data may consist of shoreline segments and attribute data describing each one.

While not a part of the data layers referenced by Petersen, et. al. (2002) for protection strategies or necessarily one of the FGDC data themes, the SCAT data layer is a useful, locally generated data set that allows for dynamic display of shoreline conditions as a cleanup following an incident progresses.

Petersen, et.al. (2002) notes that commonly mapped human use resources are typically sorted into four classifications: recreation/access, management areas, resource extraction and cultural resources (Table 1). Properly grouped data layers allow the display of pertinent data with minimum navigation by users. It may be necessary to duplicate layers in the Table of Contents in ArcGIS or include duplicate layers (one an open polygon,
the other filled, for instance) in order to simplify data display or clarify the data representation on the map.

Table 1. Some common human-use data layers (adapted from Petersen, et. al. 2002)

<table>
<thead>
<tr>
<th>Data Element</th>
<th>Sub-element</th>
<th>Mapped areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreation/access</td>
<td>Vehicle access</td>
<td>Vehicular access to shorelines</td>
</tr>
<tr>
<td></td>
<td>Airports/helipads</td>
<td>Airports, landing strips, Designated helicopter landing areas</td>
</tr>
<tr>
<td></td>
<td>Beach</td>
<td>High use recreational beaches</td>
</tr>
<tr>
<td></td>
<td>Boat ramp</td>
<td>Water access for small boats, typically no facilities</td>
</tr>
<tr>
<td></td>
<td>Marina</td>
<td>Water access for small boats, typically fuel, service, docks, ramp etc available, see attributes</td>
</tr>
<tr>
<td></td>
<td>Recreational Fishing</td>
<td></td>
</tr>
<tr>
<td>Management areas</td>
<td>Designated critical habitat</td>
<td>Designated by USFWS</td>
</tr>
<tr>
<td></td>
<td>Wildlife refuge, state parks, wildlife preserve</td>
<td>Federal state and local parks, wildlife areas</td>
</tr>
<tr>
<td>Resource extraction</td>
<td>Aquaculture</td>
<td>Hatcheries, fish ponds, etc</td>
</tr>
<tr>
<td></td>
<td>Water intakes</td>
<td>Drinking, cooling, industrial water intakes</td>
</tr>
<tr>
<td>Cultural resources</td>
<td>Archaeological sites</td>
<td>Water, coastal or wetland associated features</td>
</tr>
<tr>
<td></td>
<td>Historical sites</td>
<td>Water, coastal or wetland associated features</td>
</tr>
</tbody>
</table>
Chapter Six

Proposed Western Lake Erie Protection Strategy Map Design

At present (Summer 2009), there is standard but limited data and few graphic representations of booming strategies for protection strategies in the western Lake Erie plan. Ultimately, an important goal of this project is to improve the clarity and usability of the containment/protection strategy maps detailed in the Western Lake Erie Area Plan. Following a presentation of the protection strategy mapping approach from various locations to the Western Lake Erie Area Committee Feb. 14, 2008, input was solicited from responders and managers regarding what data they felt is required in response map layouts and which of the protection strategy maps reviewed best met the needs and goals of the committee. The consensus was that a combination of elements from maps produced by the Northwest Area Committee for Central Puget Sound and the Snohomish River would be a reasonable starting point for developing response plans appropriate for conditions found in the western basin of Lake Erie.
6.1 Base Map Data Layers

Protection strategies are grouped geographically from the northern part of the western Lake Erie Area of Responsibility (AOR) in Monroe County MI to the eastern edge of the AOR at the mouth of the Vermilion River in eastern Erie County, OH. The Lake Erie Islands, part of Ottawa and Erie counties are also included in the AOR. Protection strategies may not exist for the entire shoreline, but are developed for sites that have been determined to be environmentally or economically sensitive. These locations will be noted with a callout on the index map which is linked to a .pdf of the strategy. Other significant points outside a protection strategy such as oil collection points, shoreline access etc. can be noted on the map as well. The protection strategy maps include multiple data sets grouped by general functionality. Base maps provide a spatial reference for the response data. Base maps may be raster imagery from various sources and of varying resolutions and may include, but are not limited to:

- Transportation networks – local roads, state, federal and interstate highways and railroads.
- Physical geography layers include the Lake Erie shoreline, major streams and a high resolution streams layer from the National Hydrographic Dataset (NHD) to provide higher spatial resolution for use when the map is zoomed in to larger scales.
• Political boundaries – township, village, city, county, state and international, in the case of the Great Lakes. It may be beneficial to create both filled and open polygons of these layers.

• NOAA navigation charts, both DRGs (scans of existing charts) and vector data containing similar data. These layers should be considered for reference only and should not be used for navigation.

• Aerial and satellite imagery at appropriate resolutions along with USGS or US Forest Service 7.5 minute quads (DRGs) can be used under the vector data layers.

These and other pertinent base map data layers are available from various federal, state and local government agencies (e.g., street networks from US Census or county auditors, hydrographic data from the US Geological Survey) usually by data download. Geocoding or address matching the location of hospitals, fire stations, police stations and other public service agencies may be necessary where such data are not already available. When a significant incident takes place, it may be possible to acquire current or very recent satellite or aerial imagery, such as that flown by NOAA after Hurricane Ike in September, 2008 (http://ngs.woc.noaa.gov/ike/IKE0000.HTM). The data/imagery is then available for analyses of affected resources. It may be possible to leverage work done by other county or state emergency management agencies to reduce the effort necessary to compile base maps.
An additional benefit of using existing base data is multiple agencies will be working from the same base map and will all reference the same data.

6.2 Response Specific Data Layers

Data layers that are specific to an Area Committee’s Area of Responsibility and are of importance to responders and planners are stacked on the base map layers. In this case, the response data layers have been sourced from the 1998 edition of the Western Lake Erie Area Contingency Plan and were prepared by the Great Lakes Commission at a reference scale of 1:24000 as indicated in the metadata. These layers include, but again, are not limited to:

- Sensitive species polygons that describe that approximate location and type of environmental sensitivity of organisms that may be threatened by contact with oil or other hazardous chemicals.

- The shoreline Environmental Sensitivity Index (ESI) provides planners with important information about the relative sensitivity of a shoreline to contact with oil. The sensitivity is related to the difficulty removing stranded oil from the shoreline and the sensitivity of plants and animals potentially affected by oil.

- The location, extent and type of public and private land managed for wildlife or conservation purposes are contained in the managed areas layer; the information is important for planning and notification in the event of an incident.
- Marinas and boat ramps are separate but similar layers that provide vital data on the location, capabilities and contact information for marinas and boat ramps. The most significant difference between the two is boat ramps when listed separately, provide access to the water and are typically not associated with a marina and may have limited dockage and services, if any are available at all.

- The petroleum pipelines layer provides the location, diameter and number of pipes in a route. Information on ownership and emergency contact are also included. This layer may be password protected for security reasons.

- Petroleum storage locations / potential spill sources provides information on the amount and kind of petroleum product stored at a particular site. This data enables planners to devise a response plan for the worst-case scenario – a release of the entire contents of a storage tank. This data too may be password protected.

- The water intakes layer provides the location and emergency contact data for water intakes both in the lake and along inland streams. Access to this layer may be password protected for security reasons.

These data layers are contained in the various Area Contingency Plans. The data may be already available as shapefiles, however some processing may be necessary to create files useful for analysis in a GIS.
6.3 Western Lake Erie Protection Strategy Page Layout

The proposed page layout for the Western Lake Erie protection strategy maps uses elements from the Central Puget Sound protection strategy maps (Northwest Area Committee, 2007) and the Snohomish River GRP (Northwest Area Committee, 2008). The index map provides a small scale (large area) overview of the area of responsibility of the area committee with links or references to pages containing response strategies (Figure 22).

The western basin of Lake Erie covers a fairly large area. An index map is necessary to give responders an overview of the area and the relative location of each protection strategy. The map contains standard base map layers appropriate to the scale with callouts for each protection strategy within the Western Lake Erie Area Committee’s AOR. Each of the callouts on the Western Lake Erie Protection Strategy Index Map is an existing protection strategy found in the Western Lake Erie Plan. Where there is no data in the existing strategy, the new data fields are left blank. The missing data will be filled in as protection strategy updates are completed. The final map when published as a .pdf will have links from the index map to each protection strategy. Where there are multiple strategies within a small area, such as the Maumee River in the Port of Toledo or the River Raisin in Monroe, MI, the link will be to a sub-index map. Like the larger index map, the sub-index map contains links to protection strategy pages.
Figure 22. Proposed Western Lake Erie Protection Strategy Index Map. This map lists all of the protection strategies found in the Western Lake Erie Area Plan. In Adobe Acrobat form, each callout will be linked to its protection strategy pages, helping to eliminate scrolling through a large document looking for a particular page.

Figure 23 is a segment of the original containment strategy map for the reach of the Maumee River on either side of the Sun Oil docks. This data is from the 1998 edition of the Western Lake Erie Plan. All of the Maumee River containment/protection strategy maps appear to use copies of NOAA navigation charts for western Lake Erie. The date of the charts is unknown and the scale, found on a separate page is unreadable as a result of
pixellation. The containment strategy maps for the Ports of Monroe, MI (River Raisin), Sandusky OH (Sandusky Bay) and Huron OH (Huron River) were developed from the same source.

These containment strategy maps are segments of a larger map and suffer from a lack of scale, index maps and legend. Pixellation renders street and feature names illegible, limiting usefulness of the maps in a response. There are some handwritten notations on the maps that are not explained, and letters that refer to a table describing the boom configuration and length requirements at each “boom deployment area” noted on the maps. General boom configurations at each collection point are noted, with an arrow indicating whether the configuration is for upstream or downstream spill movement.

Figures 24 and 25 reflect the proposed protection strategy map design for the Sun Oil docks on the Maumee River. Existing data from the 1998 edition of the Western Lake Erie Area Plan are the basis for the proposed protection strategy maps. There has been no data added to the strategies. The difference in detail, legibility and information available to planners and responders between the existing strategy map (Figure 23) and the proposed protection strategy maps (Figures 24 and 25) is dramatic.
Figure 23. Detail from existing protection strategy map “E” and table from the 1998 edition of the Western Lake Erie Plan.
Figure 24. First page of the proposed Maumee River Protection Strategy “E” from the Western Erie Area Plan. The map depicts the strategy, which in this case is appropriate for spilled product moving upstream (left) or downstream (right). The red and blue lines noting the general configuration of boom are representative of a boom cascade, not a continuous line of boom. The location of a collection point [CP] and staging area [S] is noted and the local road network is included.
Figure 25. Page 2 (back) of Maumee River Protection Strategy “E” from the Western Erie Area Plan. Tabular data pertinent to the execution of the strategy is located on this sheet.

Where there are numerous strategies within a limited area, a local index map may be necessary (Figure 26). In the western Lake Erie basin, rivers, commercial waterways and harbors may require a local index map. Each protection strategy noted on the local index map then has its own two-page strategy, documenting steps to be taken and resources required by responders to execute the pre-planned strategy at that location (Figures 24 and 25).
Figure 26. Lower Maumee River Protection Strategy Index Map. This map provides an index for Maumee River protection strategies. Use of a sub-index map such as this for river strategies limits the number of callouts on the master index map, improving index map readability.

The protection strategy pages are designed to allow adaptations to local conditions. For instance, collection points capable of accommodating collection and removal of spilled product whether the flow direction is up river (toward the head of the river) or down river (toward Lake Erie, Figures 24 and 25) have been identified. Protection strategies that can accommodate bi-directional flow have notations made to that effect.
There are standard data fields found in the same location on the front/back page set. The front page (or page 1 if not printed front/back) of the strategy (Figure 24) contains a map that consists of base map layers and an orthophotograph of sufficient spatial resolution as to be able to discern details on the ground, typically one foot to one meter per pixel spatial resolution. This map should be large enough (small scale) to provide responders with an idea what surrounds the area to be protected and an idea of how to get there. It also provides visual information about the general configuration of the boom used in the protection strategy and where the collection point may be.

The reverse side of the map (or page 2 if not front/back) contains a larger scale map of the collection point, pertinent boom anchor points and if appropriate a detail map of complex boom deployment configurations (Figure 25). Other detail maps can be included as deemed necessary by planners and incident managers or conditions. The bulk of the second page is devoted to tabular data important to the crews tasked to execute the protection strategy. During the planning stage, planners and/or responders should have visited each location and compiled an inventory of equipment required to execute the strategy.

A table containing an inventory of resources required to execute the strategy is found at the top of the page, to the right of the small-scale map of the collection point (Figure 25). This data eliminates guesswork by response
crews who, in the event of a major incident, may not be familiar with local response strategies and location or sources of response assets. Some strategies may require more resources than are available locally. Under these circumstances, a notation is made further down the page to that effect (in the “field notes” data field) and should have information about how and where the necessary resources can be obtained.

A larger table below the small-scale map and response resources table contains additional data required for a crew to effectively execute the strategy (Figure 25). The site entrance/headquarters/staging area/command post (as appropriate and determined by planners) latitude / longitude expressed as degrees, minutes, seconds which is a Coast Guard navigation standard, (Herb Oertli, USCG MSU Toledo, personal communication) and digital degrees is displayed in the first field. Either the WGS 84 or NAD 83 datum can be used along with the Universal Transverse Mercator (UTM) projection. Final determination regarding the appropriate datum and projection will be made in consultation with the Coast Guard as the project progresses. Written directions to the site from major easily recognizable intersections are contained in the second field.

A description of the booming strategy objective and the first priority boom location if appropriate are described, the type of shoreline to be protected, if applicable, is next. This may include a description of the shoreline as well as the ESI values for vulnerable shorelines within the
boundaries of the strategy. An outline of wildlife at risk is contained in the next field. This may not be significant in an area of heavy industry characterized by hard shorelines; however it becomes important elsewhere along the lakeshore where more sensitive shorelines exist. A description of the location of the staging/recovery area follows. The staging and recovery areas may not necessarily be co-located so directions to each should be part of the data contained in this field. Field Notes is a catch-all data field intended for any important information not found elsewhere in the strategy. The location of additional resources, other water access points, contact information in the event access to private property or a restricted area is necessary, etc. can be found here.
Figure 27. A river protection strategy able to accommodate movement of spilled product either upstream or down. The boom strategy representation illustrates the approximate configuration to deflect the product into the collection point; the data tables make note of changes where appropriate. Boom type symbology or icons (diversion, collection, exclusion, fire, sorbent, etc) have not yet been established.

Wind direction and strength can have a significant effect on water level in the western basin of Lake Erie and it affects the current direction on the Maumee River under certain circumstances. A fairly common occurrence in the western basin of Lake Erie is a wind blowing strongly along the long axis of the lake from the southwest or northeast for an extended period. The shallow depth of the western basin and long fetch down the lake combine to
lower or raise water levels significantly under certain circumstances (Figure 28), requiring strategies that take into account the possible reversal of water flow in the Maumee River along with a rapid increase or decrease of the water level in the western basin of the lake. These water level variations may also be accompanied by large waves. The variations in river flow direction and current velocity (Figure 29) are driven by river flow volume, wind speed and wind direction. The water level and wind gauges are located at the U.S. Coast Guard Station Toledo (air temperature, pressure and relative humidity data are also collected at this location) and the river current gauge is located near the head of commercial navigation on the Maumee River in Toledo, OH.

The data in Figures 28 and 29 were acquired concurrently.

**Great Lakes Currents: Maumee River at ADM Grain Elevator Pier (gl0201) 3 Day Time Series**

*4** flow (Outbound) is from head of the river to the lake.

Figure 29. Screen capture of Maumee River water level and wind direction data for the three-day period ending 3-31-2009.

Source: [http://glakesonline.nos.noaa.gov/monitor.html](http://glakesonline.nos.noaa.gov/monitor.html)

Data accessed 3-31-2009

An essential element not yet present on the layouts which will require development and input from higher levels of response management is the development of a naming convention for each strategy that includes the lake, strategy number, strategy name and Coast Guard District or US EPA Region number if appropriate. This information will be on the sheet with the strategy name; it will also be on the right edge of the previous strategy (assuming a left to right numbering sequence) and the left edge of the next strategy. This convention allows easy reference and access to adjacent strategies should it be necessary. Another element that must still be added to the maps subject to guidance from the Coast Guard is the application of a reference grid to the maps. The US National Grid (USNG) is based directly on the Universal Transverse Mercator (UTM) and the Military Grid Reference System (MGRS). The Federal Geospatial Data Committee has
defined the USNG as a standard reference system for emergency response for federal agencies involved in emergency response (Brooks, 2003).

6.4 SCAT / Shoreline Assessment Data Collection

Rapid, accurate, and consistent data collection during an incident is important to planners and responders for a number of reasons, not the least of which is good data makes good decisions. The established SCAT - Shoreline Cleanup Assessment Teams (term used by NOAA) or Techniques (term used by Environment Canada) - data collection methodology provides a systematic framework for collecting data describing the presence or absence and amounts of oil on the water or stranded on a shoreline.

As part of the protection strategy development process, crews who may be responsible for performing SCAT surveys in the event of a spill should collect data on shorelines as they exist before an incident occurs. Pre-incident data collection not only documents the condition of the shorelines before a spill event, it serves to supplement existing protection strategy data and can alert planners and responders to potential hazards to cleanup crews, both in the foreshore and backshore. For example, low cliffs are common along the shores of the Lake Erie Islands and Catawba Island, limiting backshore access and restricting cleanup activity to boats along the shoreline. The presence of cliffs and backshore access restrictions presented by them should be noted in the appropriate protection strategy and consideration given as
response strategies for shorelines in the area are developed. The pre-incident shoreline assessment process also helps managers determine where and when to deploy crews to execute protection strategies, recover oil from the water, remove oil from shorelines and determine when a shoreline is considered clean. It has the added benefit of familiarizing SCAT crews with the shorelines that may be affected in the event of a spill.

NOAA has several shoreline assessment forms available for assessment teams to standardize data collection activities. Data collected during pre-spill shoreline assessments should be included in layers provided in the protection strategies. This not only provides data for before – after spill comparison, but the data collection activity using the shoreline assessment forms provides practice for personnel who will eventually be responsible for shoreline assessment in the event of a spill.

Data collected and incorporated into layers using the shoreline and wetland assessment forms from NOAA (or other appropriate source) can be important for processing and making a comparison of before and after conditions easier and quicker. NOAA and Environment Canada have developed protocols for completion of SCAT forms. The forms contents and protocols for data collection are outlined in the NOAA Shoreline Assessment Manual (NOAA Office of Response and Restoration (ORR), Seattle, 2000) and Environment Canada’s The SCAT Manual (Owens and Sergy, 2000).
A geospatially enabled version of the SCAT forms are being developed by NOAA’s Office of Response and Restoration in Seattle and the University of New Hampshire’s Coastal Research Response Center (Zelo, 2000). Properly designed data entry forms will allow the use of either data collection methodology, depending on the availability of the handheld GPS computers. SCAT crews equipped with GPS enabled PDAs or ruggedized handheld GPS receiver/computers allow for faster, more accurate data collection, better consistency between crews collecting data and easier, quicker integration of the data into the planning and response database (Zelo, 2007).

An important element in developing a set of geospatially enabled protection strategies is relating tables to each other using key fields found in separate tables. The shoreline is broken into segments based on natural breaks in shoreline type, access, proximity to staging or response assets or other criteria as determined by planning personnel. Each segment is assigned a name or number. This name or number becomes a key field for linking related tables in the geodatabase. Segmentation and survey of the shoreline by trained personnel before an incident allows SCAT data collected during an incident to be quickly and accurately integrated into a response database whether the data is collected on paper forms or using a GPS enabled handheld computer. That data can then be displayed on maps available to response managers or used for further analysis of threats to resources, for
example. The SCAT data tables use the segment ID number as a key field to relate data contained in the SCAT surveys to that segment (Figure 30).

![SCAT Database Data Structure Diagram](image)

Figure 30. NOAA/Office of Response and Restoration SCAT Data Structure. This graphic gives a sense of the relations between tables in the SCAT database. Source: Coastal Response Research Center, University of New Hampshire, Durham, NH. [http://www.crrc.unh.edu/workshops/data_standards/](http://www.crrc.unh.edu/workshops/data_standards/)

6.5 Beyond Printed Maps

Geospatial technology is commonly used to create printed maps for various purposes. Producing printed maps is certainly an appropriate use of geospatial technology, but misses the real potential for analysis of data when used in emergency management applications. The map layouts produced for this paper are useful output from an ArcMap, however the analytical
capability of geospatial technology is where it can provide significantly improved situational awareness when compared to printed maps.

When an incident is of sufficient size to warrant the presence of a GIS specialist as part of the response effort, the possibilities for output include both pre-planned products such as display of results from model runs predicting the trajectory of a spill or chemical plume or print out pre-planned response documents to ad-hoc responses to requests for information from emergency planners and managers.

Up to this point, the uses of geospatial technology in this project have been for planning rather than as a decision support tool. The use of GIS for planning is certainly an appropriate use of the tool but it does not take advantage of the analysis capabilities of the technology. The US Coast Guard Marine Safety Unit (MSU) Toledo and US Environmental Protection Agency in collaboration with the Ottawa County OH Emergency Management Agency held a joint oil spill response exercise at the Ottawa County Emergency Operations Center (EOC) in Port Clinton, OH June 10, 2009. The exercise scenario had two ships (one a steamship) colliding in US waters at 41° 40’ N 83° 00’ W. The collision resulted in the release of approximately 15,000 gallons of Bunker C fuel oil into the lake. Winds were assumed to be from the northwest, which would move the oil toward the Lake Erie Islands (NOAA Drill Request Form as submitted by USCG MSU Toledo or Jan Vorhees, USCG MSU Toledo, personal communication).
An ArcReader project was created and bookmarks for printed maps at scales of approx 1:150,000 for reference maps (Figure 31) and 1:24,000 (Figure 32) for each of the Lake Erie islands in US waters (South Bass, Middle Bass and North Bass) were created. These maps contain data of potential interest to managers on a spill but are generally less useful for responders as there are no response strategies illustrated on them.

Unfortunately, a call to jury duty meant that the maps created and data collected may not have been used to full advantage and the advantages and disadvantages of using an Arc Reader or Arc Map project for on site analysis were not evaluated. The Arc Reader project and data were transferred to Jon Gulch, Federal On-Scene Coordinator for the US Environmental Protection Agency for use at his discretion during the exercise. As of this writing (July, 2009) the After Action report written after the spill has not yet been released, as a result no feedback has been received from the Area Committee members.
Figure 31. Map of Catawba Island and the Lake Erie Islands in the western basin of Lake Erie. This map was created to support the USCG/USEPA "Mistake on the Lake" oil spill exercise held June 10, 2009. The spill location for the "Mistake on the Lake" exercise is noted at the upper left. Also located on the map are water intakes, marinas and general shoreline sensitivity.
Figure 32. Map of South Bass Island prepared for the Mistake on the Lake exercise. The map contains information useful to responders – the location of marinas, water intakes, navigation buoys, sensitive species polygons (denote presence of species sensitive to oil and whether the sensitive species is terrestrial, marine or both) and shoreline sensitivity layers are displayed in this case.
To illustrate the potentially useful data that can be quickly extracted from an Arc Map project and used for decision-making, the area around the Lake Erie islands projected to be affected by the spill in the Mistake on the Lake scenario was selected and attribute data from the selected layers was displayed in tables. The area affected was determined by output from the oil spill model run by NOAA at the request of the Western Lake Erie Committee planners. A frame capture from 2200 hours on June 10, 2009 shows the projected distribution of oil some 19 hours after the simulated collision (Figure 33).
Figure 33. A screen capture from a Quicktime animation created by NOAA of the projected location of oil at 2200 hours June 10, 2009 as part of the Mistake on the Lake spill exercise. The oil in this graphic is represented by the cloud of black dots. South Bass, Middle Bass and North Bass Islands are aligned south to north along 82°50’W.
Economic and ecologic resources in the potentially affected area were selected in ArcMap and the attribute tables containing contact information and resources at risk displayed. In this exercise, no polygons describing projected oil movement were provided by the oil trajectory models making the selection of resources a best guess based on information from the animation provided by NOAA.

Figure 34. Projected oil slick movement for USCG/USEPA Mistake on the Lake exercise. Potentially affected resources (managed areas, water intakes and marinas) are highlighted in cyan, attribute data for the highlighted resources are contained in the tables below.
In this case, a quick query was created simply by selecting the assets that were in the projected path of the oil (Figure 34). The result was a set of tables containing the information necessary to contact those responsible for economic or ecologic resources that may be at risk from the spill so that appropriate responses can be taken (Figure 35).

This is by no means an exhaustive examination of the data that can be extracted from Arc Map. Queries can be developed that can display whatever data planners or responders feel is important. For instance, near real time meteorological data is available online from data buoys in the lake as well as stations along the shore. Personnel with a copy of the Arc Reader project and an internet connection can use hotlinks built into the Arc Reader project
created for the Mistake on the Lake exercise to access weather data as reported at Coast Guard stations, airports, NOAA data buoys moored in the open lake. Live or recent data from other sources, for instance USGS/NOAA river current gauges, can be made available through the ArcReader project, again as deemed appropriate or useful by planners and response management personnel. Additional data tables can be added at the discretion of the Area Committee.

6.6 Additional Data and Future Work

Some potentially useful data for the WLE AOR are available by link to external sites including but not limited to Maumee River water level and current gages (http://glakesonline.nos.noaa.gov/monitor.html, http://glakesonline.nos.noaa.gov/moncurrent.html) and USGS flow data for the Maumee River (http://waterdata.usgs.gov/usa/nwis/uv?site_no=04193500). These sites are presented as examples, there are many other data sources within the AOR that can be included. Near real-time weather data are also becoming more available on the web, including data from automated NOAA MADIS (Meteorological Assimilation Data Ingest System) sites. MADIS stations in the State of Ohio are operated by the Ohio Department of Transportation (ODOT). Data from those sites is freely available from ODOT via Buckeye
Traffic ([www.buckeyetraffic.org](http://www.buckeyetraffic.org)) and the Weather Underground ([www.wunderground.com](http://www.wunderground.com)).

![Figure 36. Screen capture of MADIS data from the Ohio Department of Transportation’s Buckeye Traffic web site ([www.buckeyetraffic.org](http://www.buckeyetraffic.org)). MADIS sites seem to be fairly evenly distributed across the state of Ohio.](image)

More information and raw data from MADIS sites for display on web sites can be obtained directly from the NOAA MADIS website ([http://madis.noaa.gov/](http://madis.noaa.gov/)) (Figure 36). It should be noted that coverage of NOAA’s MADIS sites varies from state to state. Ohio appears to have fairly even distribution of MADIS sites across the state. It appears these sites were installed and are maintained by the Ohio Department of Transportation (ODOT). These sites collect data on pavement temperature, vehicle speed and other attributes important to ODOT as well as data on weather conditions. A
somewhat limited search for MADIS sites in Michigan turned up few reporting locations. The network of MADIS stations in Michigan does not appear to have the spatial coverage found in Ohio. Other options for acquiring near real time weather data such as the Weather Underground’s personal weather station map (www.wunderground.com) are available. While these sites may not be reliable enough for operational use, they serve a useful function conveying a general idea of conditions over a broad area, particularly where there are few reliable weather reporting stations. Datasets deemed useful for planning or response can be added with the approval of the Area Committee.

While there are several areas where this project can be developed or improved, they are beyond the scope of this project. A significant area where usability and integration with existing emergency management protocols and best practices can be enhanced is the inclusion of the US National Grid (USNG) as a spatial reference. The USNG is based on the Universal Transverse Mercator projection and is the functional equivalent of the Military Grid Reference System (MGRS). The use of the USNG is not mandatory for local response organizations, but familiarization with the system is recommended. In the event of a catastrophic event where state and federal response assets are deployed, the USNG is a commonly used spatial reference system. The US Coast Guard uses degrees, minutes and seconds for its marine and aviation operations and as a result, all spatial references
should list coordinates in at least DMS, decimal degrees and US National Grid notation. Other coordinate systems can be used at the request of the Area Committee.

SCAT shoreline segmentation has yet to be completed in the western basin of Lake Erie. Segmentation and shoreline documentation prior to an incident provides response personnel with data on shoreline conditions that existed prior to an incident. A properly pre-segmented shoreline will expedite data processing in the event of an incident by linking established shoreline segments with data returned from SCAT teams, whether collected digitally or on paper. When included in a database, SCAT data can be displayed and analyzed more quickly and efficiently.

Methodologies should be developed to quickly and easily integrate output from models such as NOAA’s CAMEO (Computer Assisted Management of Emergency Operations) suite or GNOME (General NOAA Operational Modeling Environment). These models generate output describing the projected trajectory and dissipation of a spill. Output from these models provide more information for response managers to help them make better decisions.

The data collected for the Western Lake Erie maps come from various sources, most of which have coverage beyond the area of responsibility of the WLE Area Committee. Ensuring data files have adequate coverage and complete metadata is another significant task important for a project such as
this. If developed for Federal agencies, the data should have metadata that meet FGDC standards (http://www.fgdc.gov/metadata/csdgm/).

Creating an effective, operational geospatially enabled decision support system requires input from the US Coast Guard, US EPA, other members of the WLE Area Committee and related federal state and local agencies. Broadly speaking, some of the steps necessary to begin the process of integrating geospatial technology into the oil spill planning and response process include:

- Identify existing and potential protection strategy sites in AOR
- Review existing maps and data with local planning and response personnel, identify missing data
- Develop index maps for entire Western Lake Erie basin and location with numerous strategies in a limited area (Maumee R. River Raisin, Sandusky Harbor/Bay)
- Work with planning and response personnel to identify data sets and information (questions) necessary for rapid response to an incident.
- Standardize data tables for all protection strategy sites.
- Update existing data sets, collect new data and attributes
- Establish standard response map design – scale, size, layout, icons, etc.
• Create ArcReader project with appropriate data sets for incident managers.

• Publish data sets (with appropriate security for sensitive data sets) in multiple formats including shapefiles (.shp) and Google Earth files (.kmz/.kml). Other formats can be created as required.

Ongoing development of functionality using data acquired and included in the Western Lake Erie Plan will require meeting with response personnel both at the local and regional level. These discussions should help establish what information is considered important to responders at different levels in the emergency response hierarchy, whether the data is available and what form the resulting output should take. An important first effort is to educate the response community about the capabilities and limitations of geospatial technology, not just GIS. It is also important that the geospatial analysts listen to the members of the response community so a genuinely useful product is produced.

The development of geospatially enabled response plans which conform to established emergency management protocols and standards will provide consistent data to improve decision making and analysis in the event of an oil spill within the Western Lake Erie area of responsibility. By developing the plans in cooperation with local agencies and using established emergency management protocols and procedures, elements of the western Lake Erie
Area Plan can be integrated into a larger response should it become necessary.
Chapter Seven

Conclusion

The concept of pre-planning a response to a natural or man-made hazard is not a new one for emergency managers. The Environmental Sensitivity Index as an oil spill response-planning tool has been around since the late 1970s. It became more important and was developed further after the Exxon Valdez spill in Prince William Sound, Alaska in March, 1989. The spill was the catalyst for the passage of the Oil Pollution Act of 1990, which laid out, among other things, the Nation Contingency Plan. Regional and Area Contingency plans are subsets of the National Contingency Plan. The plans are designed to improve the speed and efficiency of a response in the critical hours immediately following an incident by identifying critical ecologically or economically sensitive resources to be protected and establishing a strategy to protect those resources. Geographic Response Plans, also known as protection strategies, are part of an Area Contingency Plan and define steps to be taken to protect sensitive areas that may be threatened by a spill. Until recently, most protection strategies were on paper in notebooks kept by first responders, Oil Spill Response Organizations (OSROs) and federal and state
on-scene coordinators. While the National Contingency plan requires regular updates to the plans, modification of the protection strategies, their maps and tables can be difficult; duplication and distribution of the Area Plan can be expensive and limit distribution of the document.

Geospatial technologies have matured in recent years to become a useful tool to develop, update, display and publish protection strategy data and maps. Geospatially enabled response plans can be developed, response options analyzed pre- and post-incident or post-exercise and changes made to the strategies relatively easily. The flexibility of geospatial technologies provides planners with a way to develop protection strategies for different conditions at a particular location. This study selected a limited set of protection strategies already established in the Western Lake Erie Contingency plan for display using a geographic information system; print page layouts for the data and maps were also developed.

Existing protection strategy maps in the western Lake Erie plan were evaluated for readability clarity and usefulness for responders. The quality of the maps varied widely, from high quality, legible maps of some areas to low line resolution, pixellated maps of others that are of little use. All protection strategies had consistent tabular data although it was not as extensive as that found in other strategies that were reviewed. Protection strategies from Washington State, California, Massachusetts and Florida were reviewed for their approach to representation of protection strategies. Each presented the
information differently and none appeared to use geospatial technology for analysis, only cartographic representation. Some of the Jacksonville, FL protection strategies have been exported to the .kml/.kmz format used by Google Earth. While useful for viewing (albeit sometimes slowly) the data overlaid on aerial imagery, no spatial analysis, data processing or cartography can be done. All seem to use the Adobe Acrobat .pdf file format and its functionality to some extent, most frequently for linking index maps to pertinent data elsewhere in the document. The Florida ESI maps and protection strategy index maps all have internal links to protection strategy maps and data. However, only the index maps and ESI data remain available online. Links from index maps to protection strategies are broken, limiting possible evaluations of the use of geospatial technologies in spill response planning. Approaches to protection strategy development and data representation varied, however each was deemed appropriate by the local area committees responsible for responding to an incident.

Page design and data fields to be included in the geospatially enabled protection strategies for the Western Lake Erie were found in a number of locations. The primary source of inspiration was the work done by the Northwest Area Committee in the Puget Sound GRPs (marine environment) and the Snohomish River protection strategies (riverine environment). Design elements of each were included in the draft page design, potentially useful data fields that were not included in the western Lake Erie plan were
included for review by planners and responders. An important facet of the data layout is the ability to link to dynamic data, such as SCAT data, that will allow the import of data from existing external sources during an incident. Most of the elements necessary to accomplish this task are in place, however integrating external data sets is beyond the scope of this paper. Once a page layout is approved and the appropriate data fields updated, the data fields must be populated, the maps published and included as part of the Western Lake Erie Plan. It should be noted all work done on the western Lake Erie protection strategies to this point should be considered draft, subject to revision and approval by the area committee.

The development of well-designed geospatially enabled response plans which conform to established emergency management protocols and standards will provide consistent, clearly presented data to response personnel. The updated data and maps will help improve contingency planning, data analysis and response activity in the event of an oil spill within the Western Lake Erie area of responsibility.
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