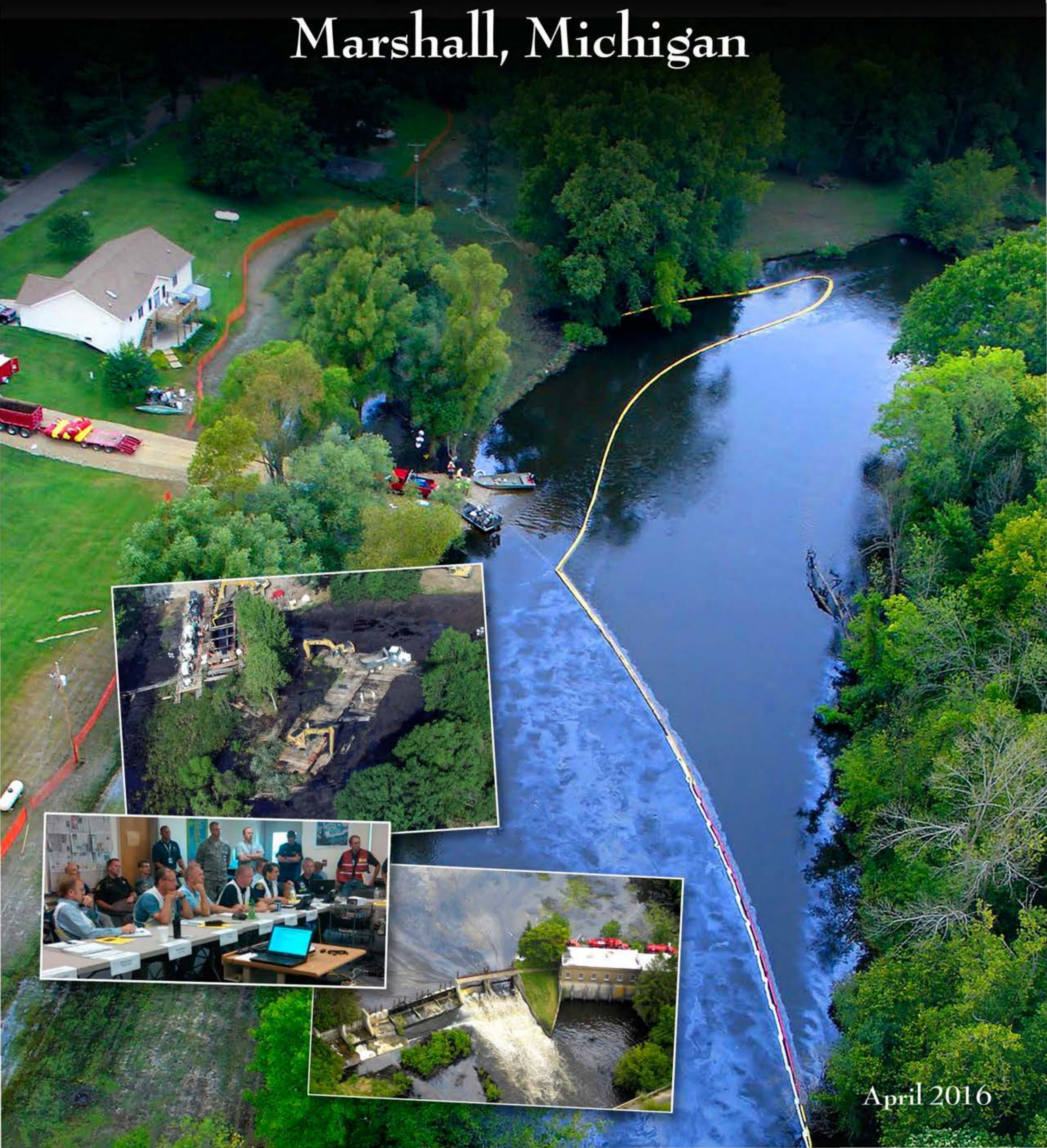
FOSC Desk Report for the Enbridge Line 6b Oil Spill Marshall, Michigan



April 2016

We would like to thank the agencies listed below and the agencies, companies, organizations and individuals that contributed to the Line 6B response efforts.

"We wanted to absolutely make sure that this massive volume of spilled oil did not even come close to threatening one of our Great Lakes; and as I go away from this incident, that will be something that I feel most proud of - the fact that we made sure the Great Lakes were not affected."
– Ralph Dollhopf

"Following what is arguably the most expansive oil spill to impact a U.S. freshwater ecosystem, the success of this cleanup is a direct result of thousands of dedicated responders, strong management and sound science."
– Jeff Kimble

EXECUTIVE SUMMARY

This report has been written as outlined in 40 Code of Federal Regulations 300.165 (b) which tasks the Federal On Scene Coordinator (FOSC) to *record the situation as it developed, the actions taken, the resources committed and the problems encountered.* This FOSC Report documents all phases of the response to the rupture and resultant diluted bitumen heavy crude oil discharge from the 30-inch Enbridge Energy, Limited Partnership and its affiliates (Enbridge) Line 6b Pipeline which occurred on or about July 25, 2010.

This report covers the period from mobilization of the first On-Scene Coordinator from the U.S. Environmental Protection Agency (EPA or Agency) on July 26, 2010 through the cessation of field activities as directed by the Agency on November 18, 2014.

Report Structure

This FOSC Report is organized into 13 sections, each with a subset of topics addressed as they pertain to the subject topic. When possible, these topics and subtopics are arranged chronologically to aid the reader in comprehension of the flow and progression of the response.

The first sections of the report include Chronology of Events, followed by the Discharge Summary and Regulatory Authority that guided the FOSC in Sections 2 and 3, respectively. Section 4, Command and Control, outlines the structure of the response as it developed and became formalized over the life of the project. This section also explains how government and responsible party (RP) resources were managed and deployed, how support areas were arranged, and regulatory compliance efforts initiated by the FOSC.

Section 5 is the largest of the report sections and explains Operations progression throughout the response. This section contains a comprehensive discussion of what work the FOSC directed Enbridge to accomplish pursuant to EPA Administrative Orders, how that work was planned and implemented, what resources were utilized, and the evolution of the strategic approaches that were ultimately necessary for success.

Section 6, Planning, details the plans and procedures used to guide and control the structure of the response and collect and disseminate information and data to the crews tasked with accomplishing the work. This effort was enhanced as described in Section 8 by a large amount of highly critical and necessary science to support operations.

Sections 9 and 10 describe the Logistics and Finance support of the overall project, respectively. In Section 11, the FOSC details how site communications were managed, which led to support from the community and dissemination of information to the public.

Section 12 presents recommendations regarding preventative measures, ways to improve response, and suggested changes that may aid future response actions.

Section 13, References, is the final section and provides a bibliography on the resources utilized in the aid of development of this report.

Section 1: Chronology

A discharge of heavy crude oil, including tar sands bitumen blended with lighter hydrocarbon diluents (also known as DilBit), occurred from the Enbridge Line 6B into Talmadge Creek, a tributary of the Kalamazoo River, in Marshall, Michigan on or about July 25, 2010 during a flood event. The floodwaters distributed the discharged Line 6B oil along 2.2 miles (mi) of Talmadge Creek and its floodplain and downstream into the Kalamazoo River channel and its backwaters and extensive overbank areas of forested floodplains, islands, and wetlands. As the discharged Line 6B oil migrated downstream, the lighter diluent volatilized. Eventually the Line 6B oil grew denser than water and/or aggregated with sediment, submerging and settling into areas of the Kalamazoo River with lower water velocity. As floodwaters receded, drapes of oil of various thicknesses covered the floodplain areas. The downstream extent of Line 6B oil was in the vicinity of the Morrow Lake Dam, approximately 40 mi downstream of the discharge location. Because the discharge went unreported for over 17 hours, response efforts were not initiated until the following day.

EPA personnel and contractors responded to the Line 6B discharge on July 26, 2010. EPA issued an initial Clean Water Act (CWA) § 311 Administrative Order requiring response actions to Enbridge on July 27, 2010.

During the response, EPA issued several orders to Enbridge directing them to conduct specific work activities. These orders consolidated and formalized the work initiated under the first few days of the emergency response and lasted through the end of EPA’s on-site presence.

Pursuant to these orders, EPA directed Enbridge to contain and recover all spilled oil, remove the contaminated soil and restore the source area where the spill originated, assess and implement cleanup plans for the downstream impacted areas of the spill, and work within the Incident Command System (ICS).

EPA also coordinated or brought in experts to coordinate community and public health monitoring and protection, recovery and rehabilitation of impacted wildlife, and the identification and assessment of submerged oil in the Kalamazoo River system.

Through the life of the response, EPA implemented managerial control of all response actions.

Section 2: Discharge Summary

Heavy rainfall prior to the discharge event and flooded river conditions during the discharge affected the fate and transport of the oil. Between July 22 and 25, 2010 approximately 5.7 inches of rain fell over the Kalamazoo River watershed in the vicinity of the spill. The oil was forced from the pipeline under pressure up through saturated hydric soils to the ground surface. Once the oil reached the ground surface it flowed through connected low-lying emergent wetlands as overland flow until it reached the flooded channel and overbank areas of Talmadge Creek. Streams of oil moved along the surface of Talmadge Creek and its overbank areas into the flooded Kalamazoo River channel and its overbank areas within the first few hours following the onset of the spill.

The discharge coincided with the peak of flooding for the Kalamazoo River on July 26, 2010, and overbank areas remained inundated for about six days after the discharge. Upon arrival at the incident, an EPA On Scene Coordinator (OSC) surveyed the extent of contamination from the discharged oil via helicopter. During the oversight, EPA observed that the oil covered the entire surface of Talmadge Creek over its 2.2 mi reach to the river, entered the Kalamazoo River, and remained as bank to bank coverage until the Ceresco Dam, which was approximately six mi downstream from the confluence of Talmadge Creek and the Kalamazoo River. At the downstream side of the dam, oil was still pervasive but diminished to approximately 50% coverage of the river surface area due to mixing and breaking up while flowing over the dam.

The discharged oil was a mixture of heavy crude oils, specifically oil sand region crudes with up to 20% diluent to make the oil viscosity conducive to movement through the pipeline. The initial response actions focused on high benzene levels in air surrounding the near shore and source area environments due to volatilization of the diluent component of the discharged oil. As the oil weathered, less volatility was associated with the material. Sediment-loaded waters and river turbulence caused by man-made and natural conditions led to the formation of oil particle aggregates and sinking of some portions of the discharged oil.

The National Transportation Safety Board issued a report with its determination on the causes of the discharge on July 10, 2012.

Section 3: Regulatory Authority

The National Contingency Plan (NCP) prescribes extraordinary requirements for EPA during an inland discharge that is declared a Spill of National Significance (SONS) or for one that is considered a “substantial threat discharge.” The Line 6B discharge clearly fell into the category of a “substantial threat discharge.” As such, from the outset, EPA affirmatively directed response actions via the FOSC and the Order. While the discharge was not formally declared a SONS, EPA Headquarters and Region 5 effectively managed it as one.

Pursuant to Section 311(b) of the CWA, the EPA Administrator has determined that discharges of oil that:

a) violate applicable clean water standards; and/or
b) cause a sheen upon or discoloration of the surface of the water or adjoining shorelines or cause a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines

may be harmful to the public health or welfare or environment of the United States (40 C.F.R. §110.3).

40 C.F.R. § 110 further states that "sludge means an aggregate of oil or oil and other matter of any kind in any form other than dredged spoil having a combined specific gravity equivalent to or greater than water[.]"

Section 311(c) of the CWA states, "the President shall, in accordance with the National Contingency Plan and any appropriate Area Contingency Plan, ensure effective and immediate removal of a discharge, and mitigation or prevention of a substantial threat of a discharge, of oil or a hazardous substance--

(i) Into or on the navigable waters;
(ii) On the adjoining shorelines to the navigable waters..."

These key provisions (and others) of the CWA, Oil Pollution Act of 1990 (OPA/1990), and associated regulations form the basis of EPA's obligation to ensure that the Line 6B discharged oil was recovered in accordance with the NCP. This included recovery of submerged oil.

Section 300.210 of the NCP states that a Regional Contingency Plan shall be prepared for each standard federal region. The Region 5 Oil and Hazardous Materials Contingency Plan provides a mechanism for coordinating responses by all federal agencies and state governments to releases of oil or hazardous substances within the region.

EPA documented and established its authorities pertaining to this response in a series of formal orders issued to Enbridge that detailed timelines, work requirements and procedures that Enbridge was required to comply with to meet the end results listed.

Section 4: Command and Control

Pursuant to the NCP, EPA directed the response using its FOSC authority for inland zone discharges and its 311(c) order authority. In addition, EPA performed the NCP requirement for response coordination with other stakeholders in accordance with 40 CFR §300.135(j) (2), and with other agencies in accordance with 40 CFR §300.135(d), in a Unified Command (UC) structure.

The FOSC also consulted with the Regional Response Team (RRT) to keep them apprised of major decisions and to discuss key aspects of the spill.

Early response organization was difficult and inhibited by lack of infrastructure suitable to house the large response incident management teams that were forming. The arrival of ICS-experienced EPA, U.S. Coast Guard (USCG), and U.S. Department of Agriculture (USDA) staff improved communications capability and logistics buildup for Incident Command Post (ICP) development. ICS organization progressed rapidly over the first few days of the response. This resulted in EPA-led implementation of a classic ICS planning cycle, Incident Action Plan (IAP) development, and ultimately gradual transition of responsibility for those components to Enbridge following the first 30 days of the response. The EPA FOSC retained his role as the lead Incident Commander throughout the response.

The UC included EPA, Enbridge, Michigan State Police (MSP), Michigan Department of Community Health (MDCH), and Michigan Department of Environmental Quality (MDEQ), as well as the Calhoun County Health Department, Calhoun County Emergency Management Agency, Kalamazoo County Health and Community Services Department, Kalamazoo County Sheriff, and the City of Battle Creek at the local level.

As the response continued through the fall and winter of 2010, some state and local UC members struggled with the competing demands of UC participation and their regular agency duties. This eventually resulted in the evolution of their participation into a multiagency coordination group (MAC). In the summer of 2013, nearly three years following the discharge, the MAC was dissolved. Some MAC participants continued to work with EPA and MDEQ through routine stakeholder information sharing sessions.

From the outset of response activities, EPA established a policy of outreach and information sharing with stakeholders and appropriate trustees. Liaison officers and community involvement staff assisted the FOSC with these priorities.

To manage an expansive site that included over 40 miles of contaminated riverine and overbank environments, EPA divided the site into geographical boundaries. In essence, five divisions of varying size were created to organize the response into manageable geographic zones. These zones were split into two branches. Each branch was overseen by a director, who in turn had division or group Supervisors assisting with IAP task implementation for the work crews.

Support functions were located outside the spill zone and included such activities as staging areas, dredge dewatering pads, decontamination pads, waste and liquid oil storage areas, wildlife rehabilitation centers, sample processing areas, and command post space.

Section 5: Operations

On July 26, 2010 Enbridge notified EPA of the discharge via a spill report from the National Response Center (NRC# 948903). EPA deployed the closest available EPA personnel that were on-call for emergency response. At approximately 16:30 hours, the first OSC arrived at Talmadge Creek and observed oil flowing in such amounts that water was not observable.

The second OSC arrived on-site and accompanied Enbridge on a helicopter over flight to further assess the situation. Talmadge Creek and the Kalamazoo River, from the confluence with Talmadge Creek to Ceresco Dam, were covered with bank-to-bank oil. Significant oil was also observed in the floodplain in many areas.

During the initial hours of the response, Enbridge did not have the resources on site to adequately manage a spill of this magnitude. Enbridge was not familiar with local response resources and was mobilizing contractors from Minnesota. EPA provided Enbridge with contact information for local contractors and began mobilizing its own Emergency and Rapid Removal Service (ERRS) contractors. EPA's ERRS contractors were on site on the morning of July 28, 2010 to supplement the containment and oil recovery operations being performed by Enbridge. Gross oil recovery activities were implemented during this time period with a focus on immediate containment and recovery of free oil. Containment and recovery response activities were conducted at the best recovery locations available until more suitable locations were located.

To manage the expanding geographic spread of the response, the UC Planning and Operations Sections divided the site into five geographical response areas, Divisions A through E, and waste storage areas.

Early phases of the response included initial emergency response actions designed to ensure the discharged oil on the surface of the water had been properly contained by deployment of protective, collection, and sorbent boom. Additionally, this phase of the response included a significant air monitoring component designed to confirm that the air toxics levels from diluent volatilization had decreased, and a surface oil recovery phase that included oil recovery from the water surface, which was initiated while many containment activities were still occurring. As a main component of this phase, EPA established a boundary at Morrow Lake as the downstream extent that surface oil would be allowed to migrate. An ultimate goal of EPA was creating appropriate collection points along the transport trajectory of the discharge while still ensuring that no discharged oil from this spill would reach Lake Michigan. This was successfully achieved by rapid mobilization of contractors and equipment by both Enbridge and EPA after EPA arrived on scene and began directing the response. EPA also focused heavily in these early containment and recovery phases on worker and community health and safety and initiated air monitoring and sampling programs to further this effort.

EPA conducted long term response actions, which included all actions from the implementation of work activities shortly after initial surface oil containment was deployed to the last walk through of the site by the FOSC on November 18, 2014. This covers the activities directed by EPA, and implemented primarily by Enbridge and its contract staff, and conducted as part of the ICS structure at the site. These activities included: collection of 766,228 gallons of discharged oil from surface waters; recovery of approximately 435,000 gallons of oil from other sources, including oil-saturated soils, debris, sorbent material, and water treatment; agitation of submerged oil; sediment dredging in numerous areas of the river over a several year span; iterative assessment activities and coordination with MDEQ to transition the project oversight; and direction to MDEQ at appropriate points in the response effort.

The long term cleanup and recovery phase of this response included activities conducted by EPA and will be monitored by MDEQ, which will also direct some long term remediation necessary for compliance with state regulations.

The long term cleanup goals of this response action were advanced by the work EPA directed pursuant to the orders. Concurrent with EPA's direction of Enbridge, MDEQ initiated its own Order and criteria for Enbridge to bring them into compliance with the State of Michigan's cleanup criteria. EPA first transitioned the remedial investigation and restoration of Talmadge Creek to MDEQ, followed by overbank sites, and eventually all continuing site activities when Enbridge finally completed their obligations for cleanup pursuant to EPA's 2013 Order. The site was fully transitioned from EPA to MDEQ as lead for oversight and direction in November 2014.

Section 6: Safety

Consistent with the NCP, worker health and safety were a primary concern for the FOSC. Occupational Safety and Health Administration and Michigan Occupational Safety and Health Administration requirements for safety and training provided the minimum safety requirements for the response. As part of the Order issued by the FOSC, Enbridge was required to submit a Health and Safety Plan for response activities to the FOSC. The duration of this response resulted in additional hazards not necessarily encountered during a typical response lasting weeks or even months. The hazards and risks associated with flooding, heat, chemical exposure, drowning, fatigue, noise, poisonous plants, biting and stinging insects, animal contact and recovery, traffic congestion, heavy equipment use, and aviation and boating operations, as well as numerous other hazards, made work complex.

The unique nature and duration of this response proved to be challenging from a safety perspective. However, the safety program, as originally enacted and as evolved, was effective, efficient, and highly successful in ensuring that no serious worker injuries resulted over the course of this 48 month effort. The duration of the event created weather-related hazards running the gamut of year-round weather conditions. The nature of the work also included safety-related hazards associated with air toxics, boating operations, heavy equipment use, construction, and process safety, as well as working long hours for many consecutive days and long time periods. Despite these challenges, safety was a positive component within the response and the injury rate was low.

The response organization embraced safety and maintained a daily focus on events. Situational awareness was the cornerstone of the safety program, whereby workers and observers alike understood the task to be done, the hazards associated with the task, and were aware of predictive, protective, and corrective measures to take. Workers and observers were active participants in the safety process. An aggressive incident reporting process allowed investigation, mitigation, and communication to occur on a just-in-time basis. Near-miss events received the same focus as other events and became a key component of this successful program.

Governmental response agencies and Enbridge took actions to prevent injury, illness, and hazardous materials exposure to both workers and the public. Additionally, actions were taken to ensure the safety of drinking water and fish consumption and to monitor the potential short-term and general long-term health effects to those areas and communities affected by the discharge. The Safety Officer was a critical part of the command staff established by the FOSC within the ICS structure.

Even during the first months of the response when the safety program was still evolving and over 2,000 workers were assembled to provide a cohesive response, the program is viewed as a success based on both the limited number and lack of severity of incidents reported.

As required by the NCP, protection of public health was also a primary objective of the response actions. The FOSC worked with experts within federal, state, and local agencies to protect the public safety. Information regarding the cleanup efforts, air quality testing, drinking and contact water safety, irrigation, and livestock and wildlife affects was distributed in numerous ways, including press interviews, briefings, public meetings, print material, the EPA website, and state agency websites.

The FOSC, in coordination with state and local health and safety agencies, enacted several key actions to protect the public from the discharge's impacts. EPA implemented an extensive air monitoring and sampling program throughout the response in areas potentially affected by the discharge. State and local health agencies enacted a voluntary evacuation of residential areas as a precautionary measure by using EPA-generated data. Surface water recreational usage bans, irrigation and livestock watering bans, and fish advisories were also enacted.

Section 7: Planning

The Planning Section was responsible for the collection, evaluation, and communication of information to support field operations within the ICS structure. Gathering accurate and timely information for the FOSC and Operations Section was crucial not only during the initial phase of the incident when response and staffing needs were dynamic, but also throughout the extended portion of the response where field operations and related functions were weather and season dependent.

The Planning Section employed field observers to confirm information provided by field workers at the end of each day.

The Planning Section also facilitated all meetings under the planning cycle and worked these plans into the IAP for each work cycle. At the outset of the response, the IAPs were created and signed off by UC on a daily basis to cover a 24-hour work period. By the end of the project, the planning cycle and work cycle were lengthened to a two-week work period. This was achievable due to the repetitive and focused nature of activities during the 2014 construction season.

The Environmental Unit within the Planning Section supported the development of a multidisciplinary, multi-agency Environmental Advisory Group to study site conditions and plans and to assist by advising the FOSC on these matters. The FOSC later expanded this group and renamed it the Scientific Support Advisory Group (SSAG). This group consisted of individual experts who advised the FOSC on such topics as submerged oil quantification, ebullition, and effects of agitation, among other tasks.

The Situation Unit was also a critical component during the entirety of response efforts and kept the FOSC informed of field conditions and work status. This was accomplished by field observations via foot traffic, floating the river on boats, and aerial overflights to capture photographic documentation of current conditions. The Geographical Information Systems personnel also assisted with updates to the FOSC and others by converting the information gathered by field teams into geographic visuals for presentations. This allowed the UC and FOSC, who often could not visit the widespread field locations, to visualize the immensity and complexity of daily work occurring throughout the site.

Two final and massive components of the Planning Section were the Data Management and Documentation Units. Both of these units managed an incredibly immense amount of information and categorized and stored it in such a way that it remained accessible to the FOSC.

Section 8: Science-Based Support of the Response

The removal of gross quantities of oil using conventional methods was effective during the initial phases of the response, when more than an estimated 766,000 gallons of oil were recovered. However, reassessment activities performed after the initial phase of the response confirmed the presence of submerged oil throughout many affected portions of the Kalamazoo River. As a result of the extent of submerged oil detected in the affected waterways in 2011, it became evident that additional scienctific initiatives were necessary to understand the distribution and characteristics of the remaining submerged oil. Therefore, the FOSC directed several scientific evaluations to provide information necessary to equip the Operations Section with technically sound information on which to base ongoing response actions. The FOSC assembled a multidisciplinary team of national experts to provide advice pursuant to their respective individual areas of experise. This was known as the Scientific Support Coordination Group (SSCG). Expertise of individuals from the SSCG helped to guide the scientific evaluations discussed below and in Section 8 of the report.

The FOSC's science directives examined several lines of evidence to develop a better understanding of the remaining oil distribution and behavior. These multiple lines of evidence helped define the extent, fate, and transport characteristics of the remaining oil and ultimately better informed the FOSC to direct the final response strategy via dredging of impoundments and sediment traps to remove remaining oil and balance final recovery effectiveness with a need to do no additional harm to the environment.

Activities conducted in this effort included:

- a review and study of the geomorphology of the river,
- a study on the effects of temperature on re-suspension of the weathered oil,
- a study of the effects of biodegradation on the submerged oil,
- fluvial geomorphological science and poling validation,
- comprehensive mapping of sheen,
- several complex and innovative riverine environment modeling efforts,
- establishing oil chemistry procedures to differentiate Line 6b oil from background hydrocarbons,
- quantification of the submerged Line 6b oil remaining in the river system, and
- a net environmental benefits assessment.

All of these activities were designed to support the FOSC with information to make the best decisions possible regarding the response efforts.

Section 9: Logistics

Effective logistics support was critical to ensuring that all resources required to conduct response operations were delivered. Enbridge, being the major provider of response resources, including personnel, equipment, and materials, implemented logistics in a manner independent of EPA via its normal corporate procurement mechanisms. EPA's and Enbridge's respective logistics organizations each provided their own logistics personnel to support their respective organizations. All necessary coordination between them was achieved by structured organizational interaction within the overall ICS.

This section of the following report will provide a roughly chronological discussion of important logistics considerations and events that EPA, Enbridge, and other early UC entities were confronted with during successive phases of the response.

One major logistics issue was the establishment of an appropriate Command Post. During the life of this response, the Command Post was moved several times to support the growing and subsequent waning of resources deployed to handle the operations.

Other logistics issues discussed relate to air operations, securing of supplies and services, office logistics support, and general site procurement support.

Section 10: Finance

Funding for oil spill responses that affect navigable waterways is provided by the Oil Spill Liability Trust Fund (OSLTF), which is maintained by the USCG. The OPA/1990 authorizes the use of the OSLTF for oil spill response. FOSCs can access the OSLTF by calling the National Pollution Funds Center (NPFC) or by using the Ceiling and Number Assignment Processing System (CANAPS).

On July 26, 2010 EPA Region 5 personnel requested funding from the OSLTF using CANAPS. A Federal Pollution Number (FPN) was established for the response, an initial ceiling of $25,000 was provided, and a case manager was assigned. Once the first responding OSCs were on-scene, it became apparent that the $25,000 ceiling would be quickly exhausted. EPA requested and received a ceiling increase to $300,000 from the NPFC. As the response continued, the ceiling was raised several times at the request of the FOSC. By the end of the second week of the response, the FPN ceiling was at $11 million.

Due to the size of the spill and the funding requests through the NPFC, the regional manager and case manager from the NPFC visited the response to meet with EPA staff and gain a direct sense of how long the response would continue and for what the requested funds were being used. FPN ceilings over $250,000 require an OPA 90 Project Plan (OPA 90 PP) to be written explaining the response situation, what the funds will be used for, and estimated future costs. On August 6, 2010 the first OPA 90 PP for the response was submitted to the NPFC with an estimated expenditure of $27 million. The daily burn rate was estimated at $470,000 per day. Updated OPA 90 PPs were submitted as appropriate when funding requests exceeded the initial cost estimates. As of September 2014, the latest OPA 90 PP for the response requested the ceiling be raised to $69,250,000.

EPA has an Interagency Agreement (IAG) with the USCG NPFC authorizing funding from the OSLTF. Since this single response was estimated to exceed the funding EPA had from the IAG at the time, the Region 5 Office coordinated with headquarters to request an amendment to the IAG to increase funding. As Fiscal Year 2010 ended and Fiscal Year 2011 began, funding was added to the IAG to specifically ensure that Region 5 would have sufficient funds to continue this response.

Enbridge, as the RP, has the responsibility to pay for cleanup costs and to reimburse the OSLTF.

Section 11: Communications

Through all phases of the Enbridge Line 6b Oil Spill Response, effective internal and external communication was an important component of the work process. Early communication efforts were bolstered by support from both internal and external personnel to assist the IC in messaging to the public at large.

This section discusses the forms of communication used through each stage of the project and how that effort progressed. A range of tools including Public Meetings, Fact Sheets, and other outreach was utilized to share information from the response efforts to the community.

Section 12: Recommendations

The response to this major incident occurring well inland from the coastal zone highlights the importance of area planning being extended to all geographic areas of Region 5, not just the areas where we encounter the coastal zone jurisdictional breaks with USCG. The lessons learned from this response should be used as a tool by FOSCs when dealing with future heavy oil or diluted bitumen spills to freshwater. Key recommendations are listed below.

- Use conventional techniques for containment and recovery before the weathering window closes and oil sinks.
- Put submerged oil containment systems in place robustly and early.
- Be prepared to conduct aggressive air monitoring and sampling to protect public health and worker safety.
- Practice strong area planning to optimize strong response organization early on.
- Initiate the science aspects of response support early to support the ultimate cleanup goals.

Section 13: References

This is a list of sources cited in the development of this report.

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1. Chronology

A discharge of heavy crude oil, including tar sands bitumen blended with lighter hydrocarbon diluents (also known as DilBit), occurred from Enbridge Energy, Limited Partnership and its affiliates (Enbridge) Line 6B into Talmadge Creek, a tributary of the Kalamazoo River, in Marshall, Michigan on or about July 25, 2010 during a flood event. The floodwaters distributed the discharged Line 6B oil along 2.2 miles (mi) of Talmadge Creek and its floodplain and downstream into the Kalamazoo River channel and its backwaters and extensive overbank areas of forested floodplains, islands, and wetlands. As the discharged Line 6B oil migrated downstream, the lighter diluent volatilized. Eventually the Line 6B oil became denser than water and/or became aggregated with sediment, submerged, and settled into areas of the Kalamazoo River with lower water velocity. As floodwaters receded, drapes of oil of various thicknesses covered the floodplain areas. The downstream extent of Line 6B oil was in the vicinity of the Morrow Lake Dam, approximately 40 mi downstream of the discharge location. Because the discharge went unreported for over 17 hours, response efforts were not initiated until the following day.

U.S. Environmental Protection Agency (EPA) personnel and contractors responded to the Line 6B discharge on July 26, 2010. The following day, EPA issued an initial Order (Order) to Enbridge requiring response actions. EPA issued the Order pursuant to the authority vested in the President of the United States by Section 311(c) of the Federal Water Pollution Control Act §1321(c), as amended, and commonly known as the Clean Water Act (CWA). The presidential authority has been delegated to EPA by Executive Order Number 12777. The amended Clean Water Act also includes the Oil Pollution Act of 1990 (OPA/1990), 33 U.S.C. §2701 *et seq*.

1.1. Containment/Recovery

Concurrent with air quality monitoring and sampling to ensure public health and worker safety, EPA oversaw protective containment and recovery of discharged Line 6B oil.

Immediately upon arriving at the scene, EPA directed Enbridge to deploy containment devices in strategic locations along the spill path. Containment installation began on July 26, 2010 and continued thereafter throughout the spill response. Sorbent and containment boom were initially placed on Talmadge Creek, on the first 12 mi of the Kalamazoo River (downstream of its confluence with Talmadge Creek), and at Morrow Lake. On July 27, 2010 containment was installed at additional locations in the spill path (Figure 1).

Figure 1 – Discharged Oil Accumulating Upstream of Ceresco Dam (7/26/2010)

Oil collected at the boom locations was stored in mobile tanks and then transported to Enbridge's oil storage terminal in Griffith, Indiana, which is approximately 150 mi southwest of Marshall, Michigan. By July 30, 2010 EPA contractors had installed over 14,000 feet (ft) of containment boom and Enbridge had installed over 23,000 ft of boom and set up seven oil skimming locations.

1.2. Source Area

The Source Area consisted of approximately five acres of impacted wetland area between the pipe break location and Talmadge Creek. A temporary roadway was built into the Source Area using swamp mats to allow access for vacuum trucks and other heavy equipment. Three earthen berms with associated collection trenches were constructed in the Source Area to prevent the migration of oil to Talmadge Creek. Oil was recovered from the collection trenches using skimmer pumps and/or pump trucks. Various other containment and recovery equipment was deployed, including hard boom, soft boom, oil skimmers, vacuum trucks, and frac tanks. Oil-saturated soil within the Source Area was initially excavated based on visual observation of rainbow sheen.

Figure 2 – Ruptured Portion of Line 6B Pipeline

On July 26, 2010 Enbridge initiated an emergency shut-down of the pipeline and isolated the line by closing the nearest upstream and nearest downstream block valves. A sheet pile trench box was constructed in the Source Area, immediately parallel to the ruptured pipeline. The approximately 180-foot long trench box allowed for dewatering and access to the pipeline. A portion of the pipeline was exposed for 50 ft on either side of the failed pipe joint to examine for corrosion, coating condition, and other issues. Following this inspection, a 50-foot length of pipe, which included the ruptured portion (Figure 2), was removed and shipped to NTSB's Materials Laboratory. Under direction of the Pipeline and Hazardous Materials Safety Administration (PHMSA) and in accordance with 49 C.F.R. Part 195, Enbridge installed 51 ft of new pipe to repair the failed section. The trench box was removed following completion of pipeline repair, product recovery, and soil removal activities and the area was backfilled. On August 30, 2010 Enbridge successfully completed an integrity validation pressure test along 13 mi of Line 6B. PHMSA authorized a staged restart of Line 6B beginning on September 27, 2010. The restart was completed on September 28, 2010.

Significant effort was made to ensure that workers were not adversely affected by exposure to benzene and other volatile hydrocarbons associated with the discharge. Worker personal air monitoring/sampling with organic vapor monitoring badges and real-time air monitors (Combustible Gas Indicators (CGIs), Photo Ionization Detectors (PIDs), and benzene monitors) was conducted and used to delineate the hot zone within the Source Area. Level C personal protective equipment (PPE), including air-purifying respirators, was required in the hot zone. Fire resistant clothing was required throughout the entire Source Area.

The Source Area was fenced for site control. Enbridge maintained personnel at the access location to allow response traffic in and out.

1.3. Downstream Affected Areas

EPA defined the Spill Response Area to include the Source Area and all downstream waterway and overbank areas affected by the discharged oil. By July 31, 2010 EPA had divided the Spill Response Area geographically into five operational segments for operational organization arranged from upstream to downstream: Division A (source area in Marshall), Division B (Talmadge Creek), Division C (confluence of Talmadge Creek with the Kalamazoo River to the Angell Street Bridge), Division D (Angell Street Bridge to the Calhoun/Kalamazoo County line), and Division E (Calhoun/Kalamazoo County Line to Morrow Dam). The most visible effects from the spill were present in the East Branch of the response, which contained Divisions A and B. The West Branch of the response included Divisions C, D, and E.

1.4. Public Health

The Line 6B discharged oil contained benzene. Benzene is a compound that readily volatilizes when exposed to the atmosphere and is a known carcinogen. Since benzene was present, EPA directed monitoring of air in residential areas. On July 26, 2010, under EPA direction, EPA's Superfund Technical Assessment and Response Team (START) contractor began performing air monitoring for benzene in residential neighborhoods near the Spill Response Area. Persons from six residential homes voluntarily elected to evacuate on July 26, 2010. The 51st Civil Support Team of the Michigan National Guard supported air monitoring and sampling operations in the ensuing days and weeks. On July 29, 2010 the Calhoun County Public Health Department (CCPHD), in consultation with the Michigan Department of Community Health (MDCH), issued a voluntary evacuation recommendation for some residences near the Spill Response Area.

On July 29, 2010 samples of surface water (multi-level) and private drinking water wells were collected for laboratory analyses. On July 30, 2010 the first sediment samples were collected from Morrow Lake for chemical analyses.

On July 29, 2010 the public health departments issued a precautionary drinking water advisory for residents with wells located within 200 ft of the Kalamazoo River and Talmadge Creek. Enbridge provided bottled water for the affected residents. On an informal basis, Enbridge also sampled private wells as requests were received. In accordance with the July 27, 2010 Order and the September 23, 2010 Supplement to the Order, EPA directed a formal drinking water monitoring program that included wells within 200 ft of the floodplains of the affected portions of the Kalamazoo River. In addition, Enbridge conducted a hydrogeological assessment of groundwater pursuant to the September 23, 2010 Supplemental Order.

Subsequently, the CCPHD and the Kalamazoo County Health and Community Services Department (KHCS) lifted the drinking water advisory on November 4, 2010 and Enbridge no longer provided bottled water.

1.5. Wildlife

Biologists from both the Michigan Department of Natural Resources (MDNR) and U.S. Fish and Wildlife Service (USFWS) arrived at the Incident Command Post in Marshall on July 26, 2010 to provide assistance and expertise on fish, wildlife, plants, and their habitats. MDNR is the state agency with the primary authority to manage and protect Michigan's natural resources under Michigan's Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA). USFWS is the lead federal agency with authority to manage and protect migratory birds under the Migratory Bird Treaty Act and threatened and endangered species under the Endangered Species Act, among other responsibilities and authorities.

Oiled wildlife including Canada geese (Figure 3) had already been observed on July 26, 2010, so the USFWS and EPA immediately initiated a Pollution Removal Funding Authorization (PRFA) so that USFWS could provide technical assistance to EPA and oversee wildlife response operations.

Figure 3 – Oiled Canada Goose (Photograph Courtesy of USFWS)

A wildlife rehabilitation center for oiled wildlife was established by July 29, 2010.

USFWS led the wildlife response elements within the Incident Command System (ICS) until September 24, 2010, when Enbridge assumed leadership with USFWS providing oversight. During 2010, wildlife operations included reconnaissance, capture, rehabilitation, and release of oiled wildlife, as well as implementation of deterrence methods to keep wildlife away from oiled areas. The wildlife operations were performed by USFWS and their contractors, MDNR, Enbridge and their contractors (e.g. Focus Wildlife and Stantec), Michigan Department of Agriculture, U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS), Binder Park Zoo, and volunteers from other zoos, local rehabilitation groups, and the public. Enbridge and their contractors continued wildlife care over the winter of 2010/2011 and more limited wildlife operations, primarily for turtles, in 2011, 2012, and 2013.

1.6. Command Structure

EPA established a Unified Command (UC) ICS in accordance with the National Contingency Plan (NCP) on July 27, 2010. The UC included representatives from EPA, Enbridge, MDNR/Michigan Department of Environmental Quality (MDEQ), Michigan State Police (MSP)

Emergency Management Division, CCPHD, and Calhoun County Sheriff. Cooperating and Assisting Agencies to the UC included: USFWS, PHMSA, MDCH, the City of Marshall Health Department, federal Agency for Toxic Substances and Disease Registry (ATSDR), 51st Civil Support Team of the Michigan National Guard, and U.S. Coast Guard (USCG). In addition, the Federal On-Scene Coordinator (FOSC) directed that consultation with potentially affected Native American tribes begin immediately following the spill.

1.7. SCAT/Overbank

Flushing of affected shorelines (vegetation and debris) began on July 31, 2010. A Shoreline Cleanup and Assessment Technique (SCAT) program was developed. Teams were deployed on August 3, 2010 to begin a systematic visual inspection of approximately 80 mi of shoreline along the Spill Response Area.

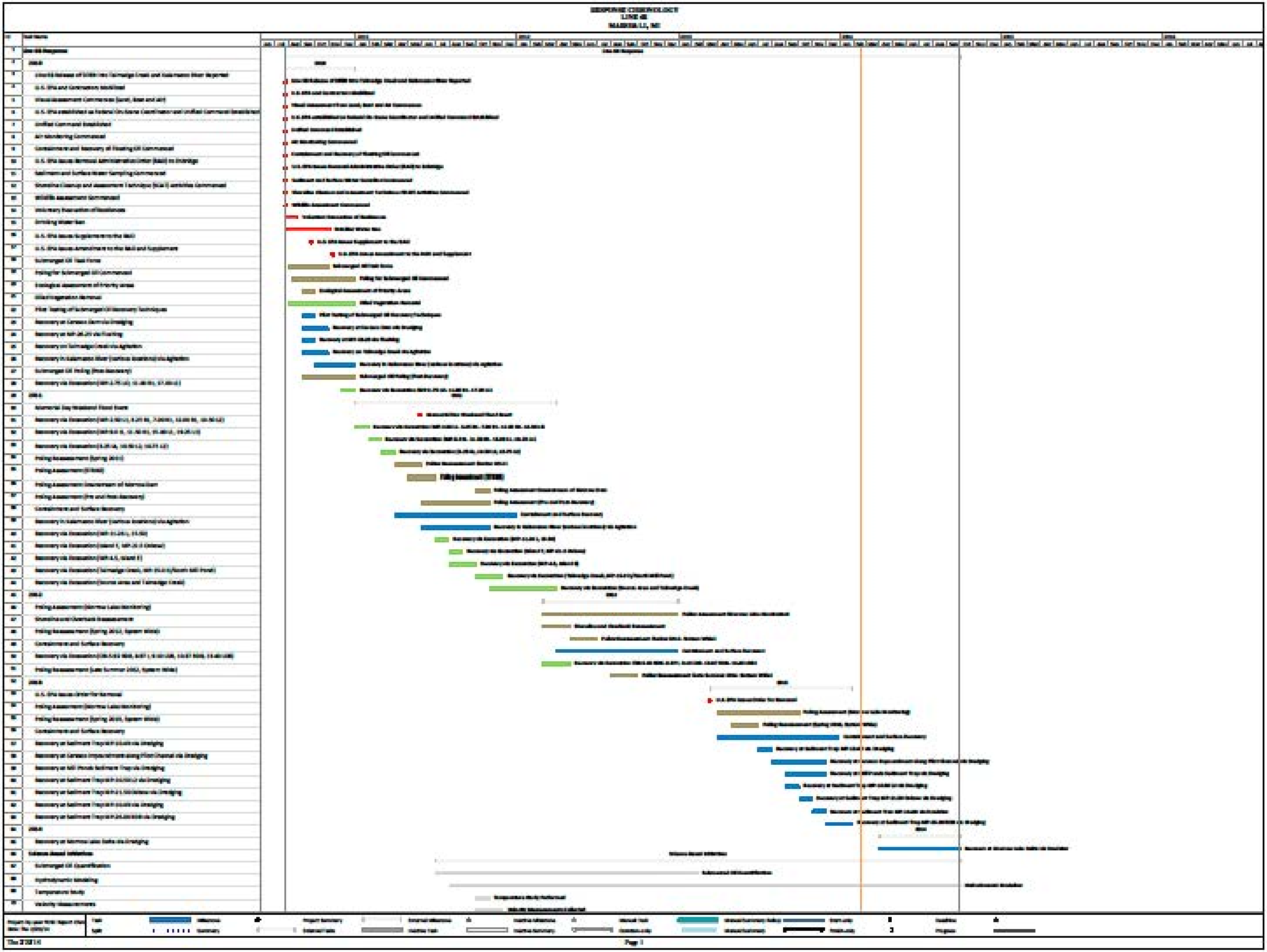
1.8. Submerged Oil

Within the first few weeks of the Line 6B oil spill, large amounts of oil were no longer present on the surface water of the river. In addition to the recovery efforts, light-end fractions of the spilled oil had volatilized during the initial portion of the response. This resulted in an increase in the oil density, which, in combination with sediment mixing caused by water turbulence from flooding and cleanup activity, caused the oil to submerge. Submerged oil generally consisted of oil entrained within and attached to sediment particles. Detection, location, mapping, and removal of the submerged oil, which was not readily visible from the water surface, became a primary operational objective in August 2010.

1.9. Response Cycle (Assessment, Respond/Recover, Monitor)

As the response progressed, a cycle incorporating continuous refinement and learning was quickly adopted. This iterative cycle consisted of three primary phases: 1) oil removal, 2) assessment of remaining oil (location and extent), and 3) monitoring of remaining oil during times when active recovery was not feasible. Results of the assessment and monitoring were then evaluated to help guide the next round of active oil recovery.

A timeline showing some of the major events or cycle components is presented in Figure 4.



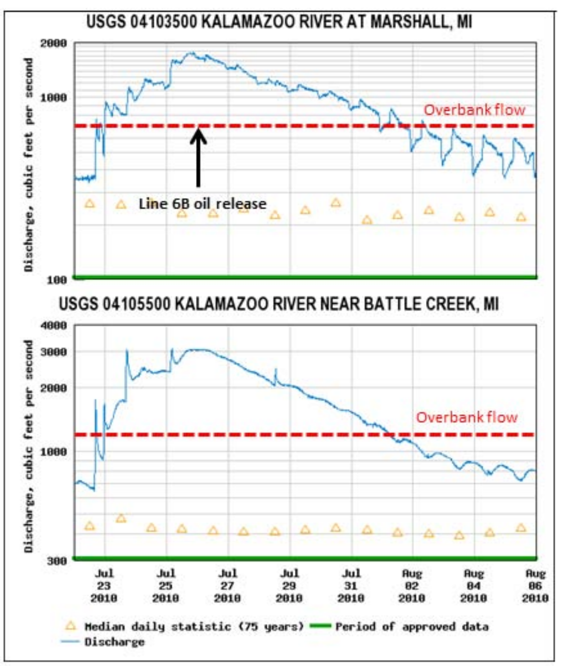
2. Discharge Summary

2.1. Setting

Heavy rainfall prior to the discharge event and flooded river conditions during the discharge affected the fate and transport of the oil. Between July 22 and 25, 2010 approximately 5.7 inches of rain fell over the Kalamazoo River watershed in the vicinity of the spill. The oil was forced from the pipeline under pressure up through saturated hydric soils to the ground surface. Once the oil reached the ground surface, it flowed through connected low-lying emergent wetlands as overland flow until it reached the flooded channel and overbank areas of Talmadge Creek. Streams of oil moved along the surface of Talmadge Creek and its overbank areas into the flooded Kalamazoo River channel and its overbank areas within the first few hours following the onset of the spill.

The discharge coincided with the peak of flooding for the Kalamazoo River on July 26, 2010 (Figure 5), and overbank areas remained inundated with water for about six days after the discharge. The U.S. Geological Survey (USGS) estimated the annual exceedance probability of the flood was four percent at the time of the spill (about a one in 25 chance that a flood of this magnitude will occur in a given year).

Figure 5 – Kalamazoo River Hydrograph (July 26, 2010)



The mainly natural state of the Kalamazoo River added to the complexity of the spatial patterns and characteristics of the discharged oil moving through a river system. The discharged oil affected over 5,000 acres of channel and overbank area along the Kalamazoo River (Table 1). About 60% of the channel (over 1,000 acres) was backwaters, impoundments, and tributary mouths, where flows were slow enough for oil to submerge and oiled sediment to be deposited. The impacted overbank area was almost 3,400 acres, with over 70% in forested, shrub, and/or emergent wetland. The distribution of the oil was highly dependent on the geomorphic setting.

Table 1 – Major Habitat Types in the Kalamazoo River

Major Habitat Types in the Kalamazoo River	Acres	Percentage of Channel Area	Percentage of Overbank Area
Backwater	114	6.2	--
Impounded Water	354	19.3	--
Morrow Lake and Tributary mouths	623	34.0	--
Flowing Channel	743	40.5	--
Bar	14	--	0.4
Emergent Wetland	347	--	10.2
Forested/Shrub Wetland	2,084	--	61.5
Island	49	--	1.4
Oxbow	38	--	1.1
Other Floodplain (Forested, Brush, Crops, Grass, Pavement, Bare Ground)	858	--	25.3
Total	5,222	100.0	100.0

Structures along the Kalamazoo River also likely affected the oil behavior. Energy from spillways at two dams, Ceresco at milepost (MP) 5.75 and Battle Creek at MP 15.7, allowed for dispersion of the oil and mixing with suspended sediments. A major tributary enters at Battle Creek from the north that almost doubles the amount of flow in the Kalamazoo River. Through the City of Battle Creek, flows are confined to a narrow cement channel from MP 15.7 to MP 16.5 and an engineered leveed channel from MP 16.5 to MP 21.5.

Upstream from Battle Creek, the Kalamazoo River meanders through mainly sandy glacial deposits with a mosaic of islands and side channels. Mississippian-aged sandstone bedrock underlies the river at various depths and discontinuously outcrops along the river, including at Ceresco Dam. Downstream of Battle Creek, the floodplain widens considerably as the river occupies an oversized glacial meltwater-derived valley with sand and gravel outwash deposits. Geomorphic complexity increases with an increase in meander bends, cutoff channels, and adjacent wetlands. The overall drop in the river from Talmadge Creek to the upstream end of Morrow Lake is about 100 ft, representing an overall average gradient of 3 ft/mi.

Sandy surficial deposits in the Kalamazoo River and Talmadge Creek watersheds have high infiltration rates, and shallow groundwater discharges into the river in most places. Two exceptions are Ceresco dam, where there is a relatively large drop in water elevation, and tight meander bends, where shallow groundwater flows across the inside of the bend, parallel to the general direction of flow in the river.

Three impoundments upstream of the Ceresco, Battle Creek, and Morrow dams have extensive soft sediment depositional areas, especially Morrow Lake and Morrow Lake Delta.

2.2. Material Discharged

In documents provided by Enbridge to EPA and/or MDEQ, there are several references to different crude oils or crude oil blends when describing the composition of the product discharge.

According to Enbridge, “based upon information obtained subsequent to the discharge and after the pipeline was restarted, it appears that the discharge may have occurred at or about the time that the latter end of a batch of Western Canadian Select (WCS) was passing through Marshall, Michigan and a batch of Cold Lake Blend (CL) crude had begun. The composition of the crude oil discharged was approximately 77.5% CL and 22.5% WCS. CL is a heavy crude blend of bitumen and condensate, produced by a number of oil companies and originating from the production field at Cold Lake, Alberta, Canada, which is located approximately 185 mi northeast of Edmonton, Alberta, Canada. WCS is a blend of existing Canadian heavy conventional and bitumen crude oils blended with sweet synthetic and condensate diluents, produced by various companies in Western Canada.”

Based on this description from Enbridge, the product in the pipeline at the time of discharge was a mixture of heavy crude oil, including oil sands bitumen, blended with lighter hydrocarbon diluents, also known as DilBit.

2.2.1. Initial Characteristics

The chromatograms of samples collected by EPA representatives and submitted to the U.S. Coast Guard Marine Safety Laboratory were consistent with a diluent/crude oil blend. Chromatograms of material collected from within the pipeline and at the terminal submitted to the MDEQ Environmental Laboratory were also consistent with a heavier crude oil blended with lighter hydrocarbons.

When discharged, the DilBit mixture had a consistency/viscosity similar to crude oil and, having a specific gravity of less than one, floated on top of the water.

2.2.2. Weathered Characteristics

After the discharged oil was exposed to the atmosphere and flowed downstream in Talmadge Creek and the Kalamazoo River, much of the lighter fraction of the DilBit volatilized. Additionally, the turbulence induced by the swiftly moving waters caused the spilled DilBit to mix with sediment. This resulting DilBit-laden sediment either suspended within the water column (enabling further downstream transport) and/or sank to the bottom of the waterways, primarily in depositional (i.e., low-velocity) areas of the Kalamazoo River.

2.3. Cause of Discharge

The National Transportation and Safety Board (NTSB), issued its report on the causation of this discharge on July 10, 2012.

2.4. Responsible Party

Line 6B is part of the Lakehead System (U.S. Mainline) owned and operated by Enbridge Energy Partners, L.P. and its affiliates (Enbridge). As a result, Enbridge is the responsible party (RP) for the Line 6B discharge.

2.5. FOSC Commentary on the Discharge

Delays in discovery and notification by Enbridge as described in the NTSB and PHMSA reports resulted in a large quantity of a volatile and yet viscous oil being discharged. The resulting geographic distribution of this oil displaying dual characteristics of volatility and tendency to sink in certain conditions (i.e., oil-particle aggregates (OPA) formed by combing wave or other energy to a combination of oil and suspended sediment) resulted in unprecedented response challenges. While discovery of the discharge was delayed for hours, there is much documentation that signs of the discharge were evident in the affected community. However, the lack of public and community awareness of the existence of Line 6B, its route, and characteristics of its products resulted in missed opportunities for the public and first responder community to compensate for Enbridge's leak detection failures. Although not the public's responsibility, citizen awareness of pipelines in their immediate neighborhood could raise the general awareness level and provide an additional reporting asset if the pipeline owner does not report the spill in a timely manner.

It is clear that enhancements in community awareness hold great potential for limiting impact from discharges through facilitating discovery and notification. In the case of Line 6B, the extent of impact, as well as the scope of response and recovery, might have been exponentially reduced had the community been knowledgeable about a pipeline running through the vicinity. Again, while it is ultimately the company's responsibility to detect and respond to leaks, more robust contingency planning and outreach involving community response organizations may be highly value-added. Such planning and outreach, when coupled with training and resources for local first responders, might also ensure that early public safety responses to future events are as strong as possible and mitigate the extent and effects of the discharge. Early first responder investigations late on July 25, 2010 to this incident focused on a tank farm in the area and not on the pipeline.

Response delays were a significant detriment in terms of allowing oil to get to the river and having what may have been a $10 to $100 million cleanup become a billion dollar cleanup. To the extent that planning involves implementation of aggressive, pre-planned response contingency measures designed to keep oil from getting to water and reduce impact area and air issues, then the submergence of oil and response costs are likely to be reduced. Implementation of predesigned engineering control activities designed to keep oil out of the Kalamazoo River and Talmadge Creek would have helped more in the Line 6B case and is a concept to be considered going forward with contingency planning for future discharges.

A more robust and accessible cadre of response contractors could also have assisted in a quicker response and mitigation effort that, in the long run, could have reduced the overall timeframe and response costs of this major cleanup effort. Enbridge plans called for contractors to be mobilized from several states away, which in turn prompted EPA to mobilize its own contract resources to help stop the advance of this spill. Enbridge did hire additional contract resources that were geographically closer to the scene after EPA directed Enbridge to do so.

The spreading of the oil over a large area exacerbated the initial weathering of the oil, causing volatilization of lighter diluent fractions to accelerate. Because the impact zone extended into populated urban environments, high levels of concern for public safety (air, direct contact, drinking water), commerce (disruption of business), and agriculture (use of river for irrigation bans) existed along the 40-mi impact zone.

Air monitoring and sampling activities to support public health decision-making were a critical function throughout the early days and weeks of the response. Widespread air monitoring and sampling were also critical to response worker safety worker considerations. Consideration needs to be given to the type and number of air samples deployed at the onset of these spills. The samples collected must provide data that the public health departments can use for conducting both short-term and long-term health consultations for the exposed human population and for determination of impact to the environment.

3. Regulatory Authority

3.1 Law and Regulation

Pursuant to Section 311(b) of the CWA, the EPA Administrator has determined that discharges of oil that:

a) violate applicable clean water standards; and/or
b) cause a sheen upon or discoloration of the surface of the water or adjoining shorelines or cause a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines

may be harmful to the public health or welfare or environment of the United States (40 C.F.R. §110.3).

40 C.F.R. § 110.1 further states that "sludge means an aggregate of oil or oil and other matter of any kind in any form other than dredged spoil having a combined specific gravity equivalent to or greater than water[.]"

Section 311(c) of the CWA states, "the President shall, in accordance with the National Contingency Plan and any appropriate Area Contingency Plan, ensure effective and immediate removal of a discharge, and mitigation or prevention of a substantial threat of a discharge, of oil or a hazardous substance--

(i) Into or on the navigable waters;
(ii) On the adjoining shorelines to the navigable waters..."

These key provisions (and others) of the CWA, OPA/1990, and associated regulations form the basis of EPA's obligation to ensure that the Line 6B discharged oil was recovered in accordance with the NCP. This included recovery of submerged oil.

3.2 National Contingency Plan

The NCP prescribes extraordinary requirements for EPA during an inland discharge that is declared a Spill of National Significance (SONS) or for one that is considered "substantial threat discharge." The Line 6B discharge clearly fell into the category of "substantial threat discharge." As such, from the outset, EPA affirmatively directed response actions via the FOSC and Order. While the discharge was not formally declared a SONS, EPA Headquarters (HQ) and Region 5 effectively managed it as one.

Section 300.210 of the NCP states that a Regional Contingency Plan shall be prepared for each standard federal region. The Region 5 Oil and Hazardous Materials Contingency Plan provides a mechanism for coordinating responses by all federal agencies and state governments to releases of oil or hazardous substances within the region. The FOSC coordinates with the Regional Response Team during large events as they are the plan holders of the Regional Contingency Plan.

The Region 5 Administrator (RA) was deployed with a senior management team to the site. In addition to supporting the FOSC, this team facilitated resource support from EPA HQ and other regions and coordinated with EPA HQ and other agencies such as the U.S. Department of Transportation (U.S. DOT), as well as the Michigan Governor's office, congressional members, and staff. The EPA team also coordinated with Non-Governmental Organizations (NGO) and the media and provided support for public meetings.

The NCP also requires that EPA implement and lead a coordination of effort by state, local, and federal agencies and tribes throughout the response. In the case of this discharge, EPA implemented a comprehensive UC and ICS and maintained a high level of coordination throughout the duration of response activities.

The FOSC enlisted the support of EPA's Environmental Response Team (ERT) for scientific support coordination and later augmented this function with a multidisciplinary assembly of science experts from government, industry, and academia. Pursuant to the NCP, the EPA FOSC consulted and coordinated routinely with Natural Resource Trustees and Tribes.

The FOSC initiated an ongoing consultation regarding completion of response actions throughout the response with the Governor of Michigan as required by the NCP. This was facilitated by a collocation of EPA and MDEQ response field offices and has been successful in ensuring that federal and state requirements for cleanup endpoints are well coordinated.

3.3 Enforcement

EPA's response authority for this discharge of oil is outlined in Section 311(c) of the CWA. To best fulfill its obligation to ensure cleanup and to direct response actions pursuant to the CWA and NCP, EPA issued an initial CWA § 311(c) administrative order to Enbridge for response actions relating to the Line 6B discharge. Issued on July 27, 2010, this order was augmented on September 23, 2010 with a "Supplement," on November 10, 2010 with an "Amendment to the Order and Supplement," and finally on March 14, 2013 with an order for additional response activities.

The immediate initiation of the Section 311(c) order process rapidly reinforced EPA's NCP obligation and authority to direct the response and linked it with the NCP obligation to coordinate – making it clear that EPA was in the lead on UC/ICS. This in turn facilitated EPA's development of the response organization of thousands of responders, garnered support from parties, enabled recovery efforts, and supported addressing the tremendous challenges. In turn, the ability to quickly organize the response command structure resulted in oil recovery of an estimated 766,000 gallons of floating Line 6B oil and another approximately 435,000 gallons of Line 6B oil in other forms (i.e., contained in soil, sediment, and debris) throughout the life of the response.

3.4 Work Required by EPA Orders

The orders (including its supplements and amendments) required Enbridge to prepare several plans to establish objectives for various recovery tasks. Enbridge submitted these plans to EPA for review, comment, and ultimate approval prior to implementation by Enbridge. A summary of the key plans is presented below.

1. Oil Recovery and Containment Work Plan (August 2010): established geographic, zone-base system (five divisions) to manage recovery operations and established recovery objectives to stop the discharge of oil from Line 6B, isolate the Source Area, and contain and recover oil in Talmadge Creek and the Kalamazoo River.

2. Source Area Response Work Plan (August 2010): established interim response measures and wildlife processing, area security, and stormwater management.

3. Response Plan for Downstream Affected Areas (July/August 2010): evaluated potential impact areas and select response actions, Kalamazoo River response and recovery, treatment recommendations, schedule, response and recovery, contingency planning, and plan modifications. The plan identified federal, state, and county stakeholders. Major attachments included SCAT Team Phase I Shoreline Cleanup Methods.

4. Pipeline Repair Work Plan (August 2010): described pipeline repair activities.

5. Waste Treatment, Transportation and Disposal (August 2010): established general and specific practices for management and tracking of recovered materials.

6. Sampling and Analysis Work Plan (August 2010): presented project organization, overview of sampling activities, data quality objectives (DQO), sampling, waste characterization sampling, product sampling, sample management, analytical approach, quality assurance, sampling equipment decontamination procedures, waste disposal and investigative derived waste, data management, and records management.

7. Health and Safety Plan (July/August 2010): provided for coordination of worker health and safety for response personnel.

8. Response Management Plan (August 2010, revised July 2011): described Enbridge staffing of ICS and identified key Enbridge staff and corporate reach back routes to ensure clear accountability pathways for EPA.

9. Downstream Containment Contingency Plan (August 2010): identified contingency contacts, resources, and measures to be implemented in the event that oil migrated past Morrow Lake dam.

10. 2012 Sampling and Analysis Work Plan (January 2012): modified the existing plan by describing sampling and analysis techniques related to work prescribed by the 2012 Consolidated Work Plan and not contemplated by the original Sampling and Analysis Work Plan.

11. Quality Assurance Project Plan (August 2010): addressed project management, sampling process design, assessment and oversight, and data validation and usability.

12. 2011 Summer Strategic Work Plan and Dredging Supplement (July 2011): described overbank oil recovery by excavation, submerged oil recovery by agitation, and reassessment work during 2011.

13. Consolidated Work Plan for Activities through 2012 (December 2011): described sediment trap and impoundment work and reassessment for 2012.

14. 2013 Submerged Oil Removal and Assessment Work Plan (May 2013): identified dredging of impoundments and sediment traps.

15. 2014 Morrow Lake Delta and Morrow Lake Submerged Oil Removal Addendum to the 2013 Submerged Oil Removal and Assessment Work Plan (August 2014): identified dredging of submerged oil areas in the Morrow Lake Delta and Morrow Lake.

4. Command and Control

4.1. Federal On-Scene Coordinator

Pursuant to the NCP, EPA directed the response using its FOSC authority for inland zone discharges and its 311(c) order authority. In addition, EPA performed the NCP requirement for response coordination with other stakeholders in accordance with 40 CFR §300.135(j) (2) and with other agencies in accordance with 40 CFR §300.135(d) in a UC structure.

4.2. Components of UC

4.2.1. Federal (EPA)

For the first few hours of EPA involvement on July 26 and 27, 2010, EPA On-Scene Coordinators (OSC) participated in a UC established by local response authorities and Enbridge. Late on July 27, 2010, following its evaluation that the discharge posed a substantial threat to human health, welfare, and the environment, EPA issued its initial CWA § 311(c) order and assumed the lead role of the UC/ICS

Early response organization was difficult and inhibited by lack of infrastructure suitable to house the large response incident management teams that were forming. The arrival of ICS-experienced EPA, USCG, and USDA staff improved communications capability and logistics buildup for ICP development. ICS organization progressed rapidly over the first few days of the response. This resulted in EPA-led implementation of a classic ICS planning cycle, Incident Action Plan (IAP) development, and ultimately gradual transition of responsibility for those components to Enbridge following the first 30 days of the response.

The UC included EPA, Enbridge, MSP, MDCH, MDEQ, City of Battle Creek, Kalamazoo County and Calhoun County.

The above agencies were each highly invested in their respective jurisdictions of public health and safety, natural resource protection, and environmental protection and coordinated with EPA and Enbridge in a UC structure until November 8, 2010.

4.3. Multi-Agency Coordination Group

As the response continued through the fall and winter of 2010, some state and local UC members struggled with the competing demands of UC participation and their regular agency duties. This eventually resulted in the evolution of their participation into a multiagency coordination group (MAC) to enable their continued engagement with EPA and Enbridge, while not requiring the same level of daily time investment from the local and state agencies as during the first four months.

In the summer of 2013, nearly three years following the discharge, the MAC was dissolved. Some MAC participants continued to work with EPA and MDEQ through routine stakeholder information sharing sessions.

4.4. Stakeholders

4.4.1. Tribal Concerns

From the onset, EPA worked closely with tribal representatives to ensure that tribal interests were considered as response actions proceeded. Early attention was focused on identification and protection of cultural and archaeological sites as required under the National Historic Preservation Act (NHPA). EPA facilitated boat tours to allow tribal representatives to view first-hand the impacts to local resources and the potential impact on tribal plans for future developments (e.g., the expansion of wild rice stands along the river).

4.4.2. Natural Resource Trustees

Natural Resource Damage Assessment (NRDA) is a process established under OPA/1990 and is intended to make the public whole for injuries to natural resources and natural resource services resulting from oil spills. The purpose of NRDA is to return the injured natural resources and natural resource services to their "baseline" condition (i.e., the condition that would have occurred but for the spill) over time and compensating for associated interim losses.

Natural Resource Trustees conduct NRDAs on behalf of the public and their actions are based on regulations found in 15 C.F.R. Part 990. These regulations were promulgated pursuant to OPA/1990 to determine the nature and extent of natural resource injuries, select appropriate restoration projects, and implement or oversee restoration. In this case, the Natural Resource Trustees performing the NRDA were: the U.S. Department of the Interior (U.S. DOI), represented by USFWS; Department of Commerce, represented by the National Oceanic and Atmospheric Administration (NOAA); Nottawaseppi Huron Band of the Potawatomi Tribe (NHBP); Match-E-Be-Nash-She-Wish Band of the Pottawatomi Tribe (Gun Lake Tribe); MDNR; MDEQ; and the Michigan Department of the Attorney General (MAG).

The USFWS initiated pre-assessment activities for the NRDA on July 26, 2010. Other Trustees joined the USFWS in pursuing the NRDA over time, and the Trustees formerly signed a formal Memorandum of Understanding (MOU) among themselves on November 5, 2010. During the weeks following July 26, 2010, the Trustees worked with Enbridge and their contractors to design and implement studies to collect ephemeral data. The NRDA teams conducting fieldwork for these studies coordinated with the larger spill response via the ICS through the Wildlife/Environmental Damage Assessment Branch in the Operations Section. This arrangement allowed the larger spill response to be aware of what the NRDA teams were doing through inclusion in the IAPs and provided the NRDA teams with access to the Spill Response Area and coverage by Health and Safety Plans.

The Trustees quickly shared data and information collected by the NRDA teams that they thought would be useful to the larger spill response (Planning and Operations Sections). This included informal observations of conditions along the river and in the floodplain, data on extent of oiling from extensive Floodplain Habitat Impact Surveys, and analytical chemistry data from water and sediment analyses that the Trustees and Enbridge performed for the NRDA with an extended list of analytes (e.g., alkylated polycyclic aromatic hydrocarbons (PAHs)) at sampling locations most relevant to impacts to freshwater mussels and early life stages of fish.

Additional information on the NRDA is available at
http://www.fws.gov/midwest/es/ec/nrda/MichiganEnbridge/index.html

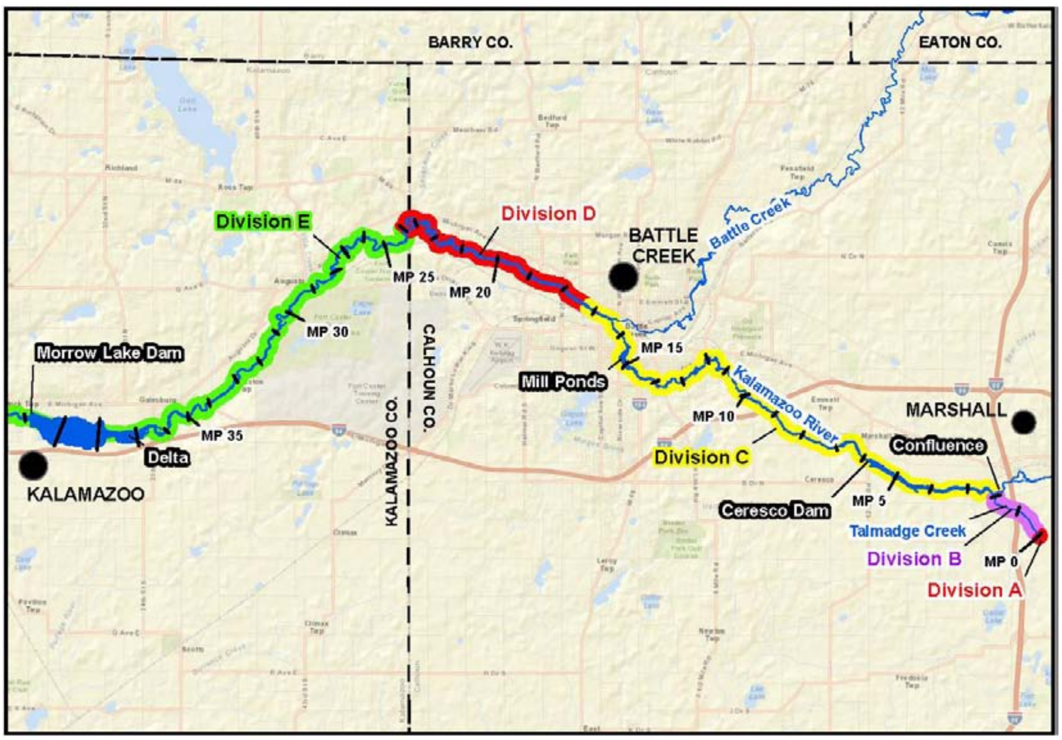
4.5. Site Organization

4.5.1. Branches and Divisions

By day three of the response, EPA established that the discharge had impacts that extended nearly 40 mi downstream of the pipeline rupture (Source Area). Simultaneously, efforts to develop an effective response organization were heavily focused on the consideration of ICS concepts of span-of-control and logistics necessary to support response operations spanning a 40 mi site.

The UC planning and operations sections elected to divide the site into two geographic branches (East and West) and then to further subdivide them into a total of five geographic divisions (A, B, C, D, E) as shown in Figure 6.

Figure 6 – Division A (Source Area) through Division E (Morrow Lake Dam)



4.6. Centralized Work/Staging Areas

Centralized facilities for the functions listed below were established. These served the various geographic divisions.

4.6.1. Boat Launches

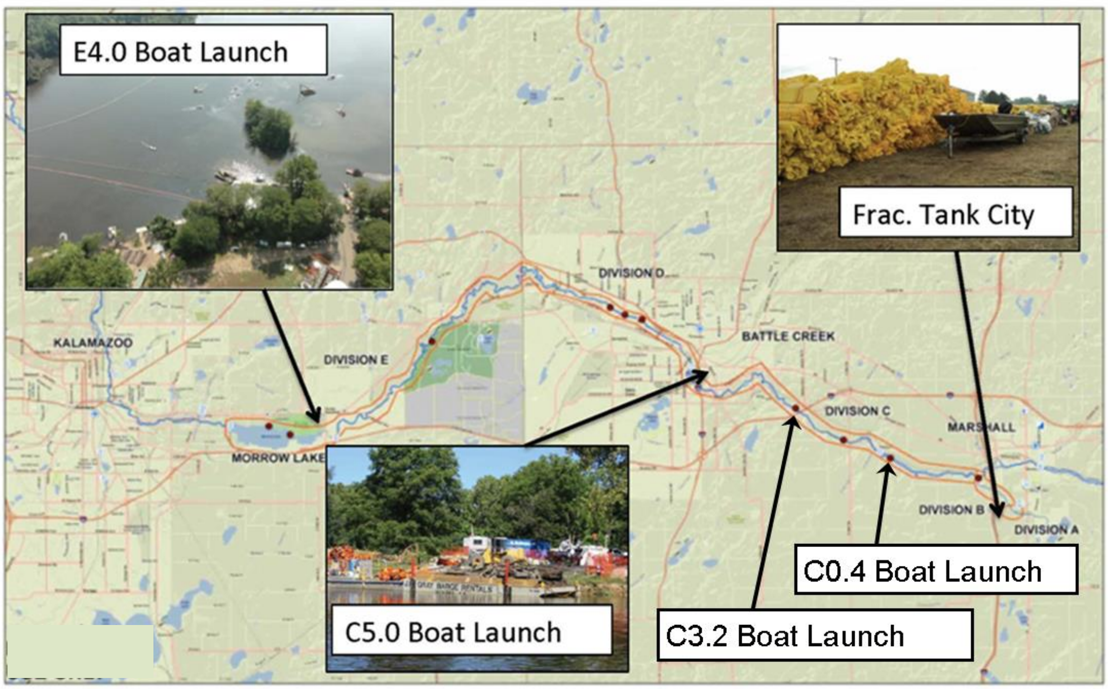
In the initial days of the response, boats and equipment were launched from numerous public and private locations throughout the entire response area. As the response continued, the majority of the boats and equipment used on the project were launched from: C0.4 boat launch, located east of the town of Ceresco; C3.2 boat launch; C5.0 boat launch in Battle Creek; E2.0 boat launch in the Fort Custer Recreational Area; E3.0 boat launch; and E4.0 boat launch on Morrow Lake.

These locations were used as the primary material staging areas throughout the remainder of the response. On occasion, boats were periodically launched upstream of the response in Marshall near Perrin Dam and at the Saylor's Landing public boat launch south of Marshall.

4.6.2. Material/Equipment Staging

At the peak of the response, Enbridge staged cleanup materials and equipment at numerous locations throughout the response area. By the end of October 2010, Enbridge stored the majority of the materials and equipment at Frac Tank City, C0.4 boat launch, C3.2 boat launch, C5.0 boat launch, and E4.0 boat launch. Enbridge used these locations (Figure 7) as the primary material staging areas throughout the remainder of the response.

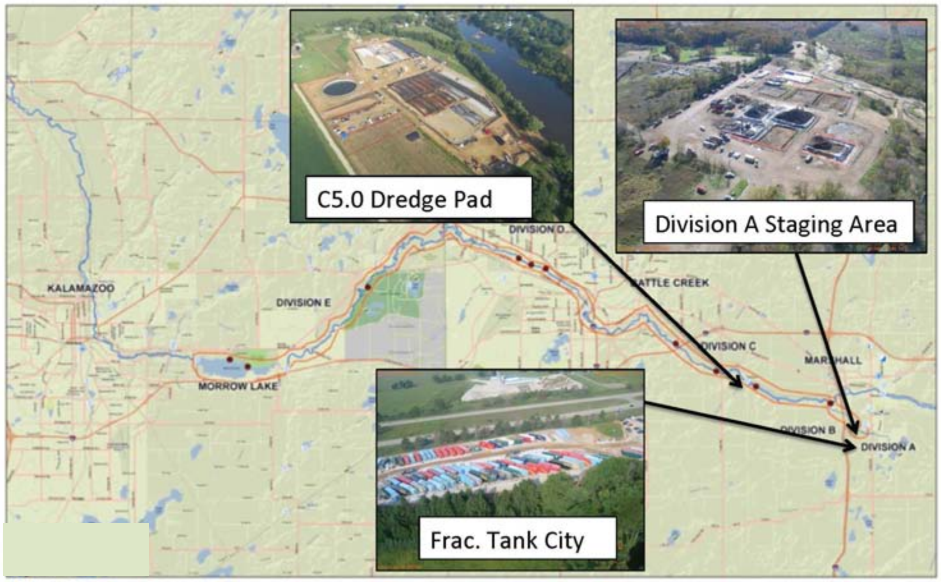
Figure 7 - Major Material and Equipment Staging Areas



4.6.3. Waste Storage/Consolidation

At the peak of the response, Enbridge staged soils removed as part of the cleanup in the Division A soil storage and treatment cells. Here the wastes were solidified and loaded for off-site transportation and disposal. Enbridge initially transported oily water and decontamination water to Frac Tank City for storage and transportation to the off-site treatment and disposal facility. As the response continued, Enbridge set up satellite waste storage areas at the various overbank excavation areas and later at the dredge pads. Petroleum-affected sediments removed during dredging operations were transported to the various dredge material storage locations, including the areas at C0.5 in Ceresco, MP 11.5, the Mill Pond Dredge Pad, and MP 21.5 (Figure 8).

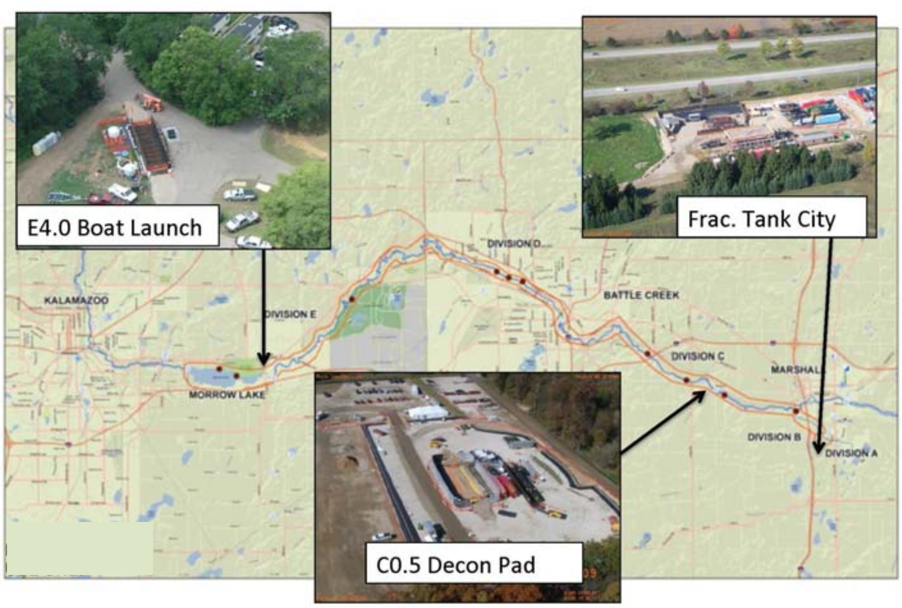
Figure 8 – Major Waste Storage and Consolidation Areas



4.6.4. Decontamination

Decontamination areas were required throughout the response area. Enbridge set up satellite decontamination stations throughout the Kalamazoo River system at locations where boom was deployed, at boat launches, and in overbank work areas. By the end of October 2010, the satellite decontamination locations located were consolidated to three locations (Figure 9) located at Soil Staging Area A, Talmadge Creek Yard 4 Staging Area Cell 12, and the C0.5 Decontamination Pad. These locations operated until December 2010, when Enbridge built a winterized decontamination area in Frac Tank City. The decontamination pads located within Frac Tank City operated as the response's primary decontamination area through the remainder of the response.

Figure 9 – Primary Decontamination Areas



4.6.5. Wildlife Rescue and Rehabilitation

In the initial days of the response, the UC established an animal rehabilitation center in a former corporate office near the intersection of Interstate 94 and Old US 27 in northern Marshall. This served as the animal rehabilitation center during the initial months of the response while Enbridge constructed a long-term care facility along the river near the C3.2 boat launch. Once this facility was completed, Enbridge transported animals needing long-term rehabilitation or those being kept over the winter to this new location. The rehabilitation center at the C3.2 boat launch served as the animal care center throughout the remainder of the response. Details of the wildlife rescue efforts are described in Section 5.11.

Figure 10 – Wildlife Rehabilitiation Locations

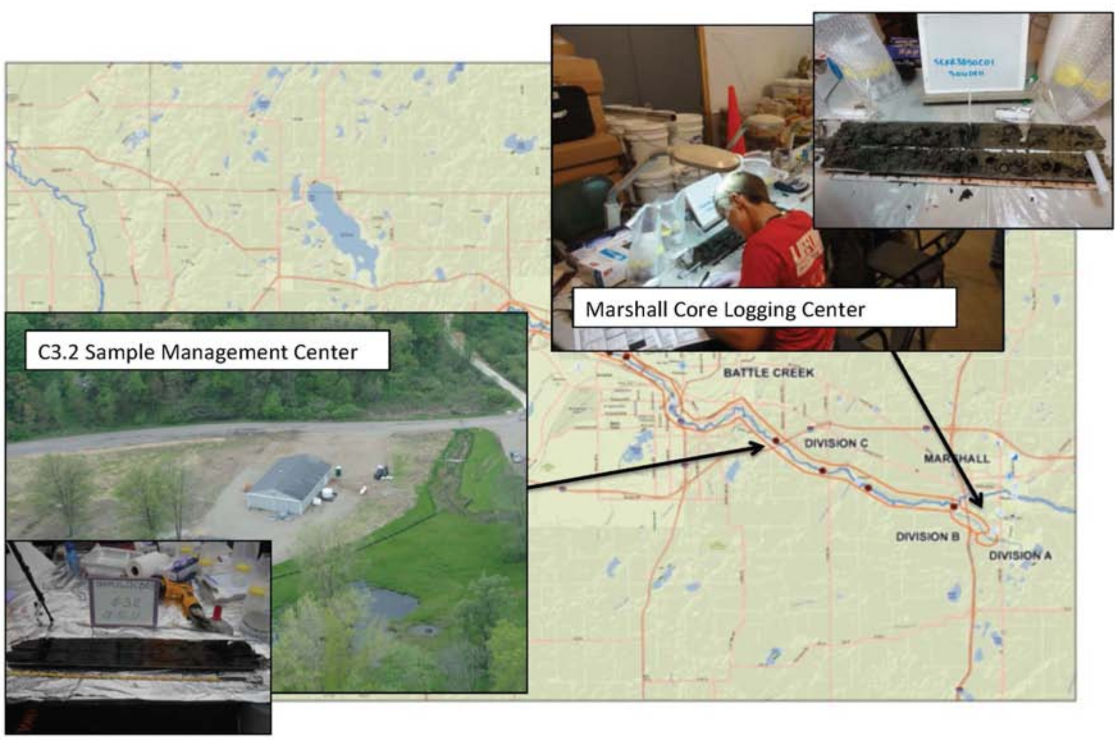
Enbridge constructed the Wildlife Rehabilitation Center (WRC) at a site located at 14998 Old U.S. 27 N. in Marshall, Michigan (Figure 10). The site had an existing building with offices, a conference room, a kitchen and a large warehouse space, and another pole barn was also present on the site. Although the main building already had electricity and plumbing installed, both systems needed to be expanded for the necessary wildlife care and washing capacity. On-demand hot water heaters were installed inside the building, and large-capacity tanks were installed just outside the building to collect wastewater. Adequate floor space for wildlife intake, rehabilitation, and conditioning allowed for flexibility in use and design. The physical structure within the building changed frequently to address the changing needs of wildlife care. Areas within the main building included an intake clinic area; stabilization and care areas for birds, mammals, and turtles; washing and recovery areas; animal food preparation; locking freezers; critical care clinic and laboratory; PPE and equipment storage; and cleaning/decontamination. The pole barn was used as a recovery area for birds following washing, as well as additional storage. A large on-site parking area allowed for convenient parking of personnel and response equipment. In addition, a large conditioning facility, complete with water pools, filtration, and secure housing, was established close to the main building, yet far enough from the main parking lot to avoid disturbances to recovering wildlife by vehicles and other equipment. Storage was available in two large sea containers.

4.6.6. Other Facilities (Core Logging, Science Testing)

In the initial days of the response, Enbridge's subcontractors set up core logging and sample management facilities in offices located near Kalamazoo Street on the southern side of Marshall. As the response activities continued, Enbridge set up a core logging and sample management facility near the C3.2 boat launch. Once this facility was operational, it served as the response's sample management center for the remainder of the project.

Enbridge also used the former private residence located at the confluence of Talmadge Creek and the Kalamazoo River along 15-Mile Road south of Marshall for various response support activities. This site was used for such tasks as sample storage, submerged oil temperature effects studies, and oil fluorescence testing. Locations of these facilities are shown in Figure 11.

Figure 11 – Core Logging and Science Facilities



4.7. Safety

From the beginning of the response actions, the UC and FOSC prioritized worker safety. As the response organization rapidly evolved, ensuring that the thousands of workers assembled were effectively protected from a variety of occupational hazards was a paramount concern of the UC. The FOSC requested the support of Occupational Safety and Health Administration (OSHA) and Michigan Occupational Safety and Health Administration (MIOSHA) to work in a consultative mode with safety officers from EPA, Enbridge, and their respective contractors.

In the early weeks of the response, public health agencies coordinated with EPA to ensure that air monitoring and sampling were effective in guiding their evaluation of potential air quality impacts and their associated responses (evacuations). Additionally, public health agencies worked with EPA to monitor potential drinking water impacts and direct contact exposures to oil or river water.

Throughout the multi-year response, there were many modifications to the safety program to adjust to changing aspects of the field work. The IAP provided a framework to ensure that designated field activities were assessed by safety professionals on a regular basis. This interactive process enabled timely changes to the safety program in order to provide consistent coordination across the entire Spill Response Area during all aspects of the response.

4.8. Liaison

EPA staffed a Liaison Officer (LNO) position within the ICS structure within approximately one week of the response starting. The LNO coordinated with other stakeholders and interested parties at the behest of the FOSC. The liaison role facilitated meaningful conversation with any non-EPA entity that had questions, concerns, or information-sharing needs. The LNO acted as the main point of contact for agency and stakeholder representatives and coordinated with them. The LNO also maintained the list of cooperating and assisting agencies and maintained their respective contact information. This list was dynamic and contact information was updated frequently.

LNO also coordinated with EPA congressional liaisons to answer controlled correspondence and other legislative and executive branch information requests pertaining to the site and information regarding the site activities.

4.8.1. Additional tasks

In the first few weeks after the discharge, the LNO also performed duties typically assigned to community relations personnel. These activities often included information gathering, response services, and dealing with media inquiries. The LNO also handled complex community concerns and issues. These tasks, typically performed by community relations personnel, delayed the LNO from being able to focus solely on liaison duties early in the response. However, EPA mobilized other staff to fill the community relations role.

4.8.2. Tours

In the first few days of the response, the EPA Region 5 Administrator, EPA Region 5 senior management, U.S. Senator Levin, U.S. Congressmen Upton and Schauer, and various state and local officials requested site tours to view the impact of the discharge on the environment. The LNO handled the coordination of on-site tours for these individuals, as well as for other partners and local stakeholders. EPA conducted tours from ground, water, and air transportation, or a combination thereof. The LNO coordinated the timing of the events and ensured appropriate trainings were in place and appropriate safety equipment was used. The LNO also ensured that the site visits did not interfere with on-site response activities.

4.8.3. Interagency coordination

The LNO coordinated with appropriate counterparts from other federal agencies, state agencies, local agencies, and tribal representatives regarding a myriad of issues throughout the first months of the response.

4.8.4. Emergency Consultation under Endangered Species Act

On July 30, 2010 EPA contacted the USFWS to request emergency consultation pursuant to section 7 of the Endangered Species Act (ESA) of 1973, as amended, for the response action to abate the oil discharges. Regulations at 50 CFR §402.05 provide federal agencies with the ability to consult in an expedited manner in situations where response activities must be taken to prevent imminent loss of human life or property.

USFWS responded on the same day with a letter that included recommendations focused on minimizing and monitoring impacts to forested areas that might be suitable habitat. USFWS concluded that the process of oil spill containment and cleanup may affect the Indiana bat but should not jeopardize the species. USFWS requested that EPA initiate consultation, once the oil spill was under control, and provide a fuller description of the emergency, a justification for the expedited consultation, and an evaluation of the response to and the impact of the emergency on Indiana bat and its habitat. On December 9, 2014 EPA requested formal consultation from USFWS. USFWS completed the Formal Section 7 Consultation for the Kalamazoo River Oil Response on May 7, 2015 with an attached report entitled "Emergency Biological Opinion for the Kalamazoo River Oil Spill Response."

4.8.5. MDEQ/MDNR

At the formation of the UC, EPA sent a liaison to the State Emergency Operations Center (State EOC) in Lansing, Michigan. Initially, the EPA liaison coordinated with officials who represented the State of Michigan. Later in the response, the EPA liaison at the State EOC left and coordination subsequently fell to the LNO at the ICP.

4.8.6. Cultural Resources

4.8.6.1. Initial National Historic Preservation Act Consultations

On August 31, 2010 the FOSC directed Enbridge to prepare a supplement to the Source Area Response Plan (SAR) and the Response Plan for Downstream Affected Areas (RPDIA) to describe its approach to ensure compliance with the NHPA 16 U.S.C. 470, et seq. Enbridge was required to, at a minimum, perform a limited Stage 1b Survey to assist in providing presence or absence determinations for historic materials and basic soil stratigraphy. Additionally, on September 5, 2010 the FOSC directed Enbridge to consult with the Michigan State Historic Preservation Office (SHPO), Office of the State Archaeologist (OSA), landowners and/or land managers, appropriate tribes, and other interested parties and to evaluate actual or potential impacts to historical properties at locations where response activities were previously conducted or were planned.

Consistent with the NHPA, EPA contacted the SHPO, the Nottawaseppi Huron Band of Potawatomi Indians, the Pokagon Band of Potawatomi Indians, and the Match-E-Be-Nash-She-Wish (Gun Lake) Band of Potawatomi (Consulting Parties) to discuss issues relating to potential historic properties and cultural resources in the response area. On September 2, 2010 EPA notified the consulting parties of its August 31, 2010 directive to Enbridge.

In response to the directive, Enbridge submitted its Approach for Field Assessment of Cultural Resources Along Talmadge Creek (Enbridge, 2010) and Approach for Field Assessment of Cultural Resources Kalamazoo River: Talmadge Creek to Morrow Lake (Enbridge, 2010); a map of previously identified historic properties within 200 ft of the river; and a report documenting activities at previously identified historic properties and effects to the properties. Enbridge completed Phase I surveys of areas where response activities had already occurred and were ongoing and provided a report entitled Summary of Section 106 Compliance Activities and Stage 1b Survey (Enbridge, 2010). The documents concluded that no archaeological resources were affected as a result of the initial response activities and indicated that as long as avoidance measures continued as described in the reports, impacts to archaeological resources were not anticipated.

On October 12, 2010 the SHPO submitted comments to EPA on Enbridge's submittals. The SHPO concurred with the findings of the reports; however, the SHPO requested that the reports be revised to include additional information. As directed by EPA, Enbridge submitted the revisions to address the SHPO comments on October 22, 2010.

On October 25, 2010 EPA provided Enbridge's October 22, 2010 reports to the Nottawaseppi Huron Band of Potawatomi Indians, the Pokagon Band of Potawatomi Indians, and the Match-E-Be-Nash-She-Wish (Gun Lake) Band of Potawatomi for their review and comment. The tribes did not provide EPA with comments or identify resources not otherwise listed in the Enbridge submittals. Therefore, EPA determined that no further NHPA Section 106 consultation with the tribes was necessary.

4.8.6.2. Phase I Field Survey

From August through October 2010, Enbridge conducted a Phase I field survey to relocate previously recorded and to identify unrecorded archaeological and aboveground resources in the area of potential effects (APE), evaluate unevaluated resources in the APE for NHPA-eligibility, and to assess potential impacts to historic properties in the APE. There were 31 archaeological and aboveground resources considered during the Phase I field survey. In November 2010, Enbridge submitted its report entitled Phase I Cultural Resources Survey of the Enbridge Energy Line 6B Pipeline Release Response in Calhoun and Kalamazoo Counties, Michigan (Enbridge, 2010) (Phase I Report) to EPA.

Following the November 2010 submittal and pursuant to the Programmatic Agreement on Protection of Historic Properties During Emergency Response under the National Oil and

Hazardous Substances Pollution Contingency Plan (1997), EPA coordinated and sought comment from the Consulting Parties on Enbridge's Phase I Report. EPA reviewed Enbridge's Phase I Report and comments submitted to EPA. While one previously recorded historic property within the aboveground APE was stained with oil, EPA agreed with Enbridge's assessment that long-term effects were not anticipated. For newly identified aboveground resources, EPA believed that while three properties were temporarily affected by the response actions, no further mitigation measures were necessary.

On September 20, 2011 EPA sent a letter to the Consulting Parties stating that EPA intended to make a no adverse effect finding regarding the response work evaluated in Enbridge's Phase I Report and provided the Consulting Parties with 30 days to file any objections to such a finding. EPA received no objections; therefore, pursuant to 36 C.F.R. Section 800.5(c), EPA's no adverse effect finding was final. On November 17, 2011 EPA approved Enbridge's Phase I Report for the evaluated areas.

4.8.6.3. Additional Cultural Resources Work

Following completion of the Phase I Report fieldwork, cultural resources work, including communication with the SHPO, OSA, Native American tribes, and/or other interested parties and Phase IB Cultural Resources Surveys, continued as necessary and included coordination with the SHPO and OSA regarding methods for winter Cultural Resources Surveys during the winter of 2010/2011.

4.8.6.4. Consultations with Other Interested Parties

In October and November 2010, Enbridge initiated communication with the Michigan Department of Transportation (MDOT), the Calhoun County Road Commission (CCRC), Heritage Battle Creek, and Michigan Historic Preservation Network (MHPN) to identify concerns regarding potential effects of the Line 6B response on historic properties. The organizations did not express concerns about aboveground resources not already identified during the aboveground resources survey.

4.9. FOSC Commentary on the Effectiveness of Command and Control

EPA's immediate expression of its enforcement authority under CWA 311(c) and fulfillment of its NCP obligation to direct response actions for a substantial threat discharge rapidly established for response participants that Enbridge was responsible and the event was federally governed through the completion of response actions. This aided in the development of a strong and cooperative UC. The rapid development of a strong UC/ICS led to substantial initial oil recovery (an estimated 766,000 gallons of free oil and an estimated 300,000 gallons of oil entrained in other media such as soil and debris) using conventional recovery strategies and tactics by allowing the effective management of nearly 2,500 responders within the initial weeks of the response.

5. Operations

5.1. Initial Response Activities

On July 26, 2010 EPA was notified of the discharge via a spill report from the National Response Center (NRC# 948903). EPA deployed the closest available EPA personnel that were on-call for emergency response. At approximately 16:30 hours, the first OSC arrived at Talmadge Creek and observed oil flowing in such amounts that the underlying surface water was not observable.

The second OSC arrived on-site and accompanied Enbridge on a helicopter over flight to further assess the situation. Talmadge Creek and the Kalamazoo River, from the confluence with Talmadge Creek to Ceresco Dam, were covered with bank-to-bank oil. Significant oil was also observed in the floodplain in many areas.

During the initial hours of the response, Enbridge did not have the resources on site to adequately manage a spill of this magnitude. Enbridge was not familiar with local response resources and was mobilizing contractors from Minnesota. EPA provided Enbridge with contact information for local contractors and began mobilizing its own Emergency and Rapid Removal Service (ERRS) contractors. EPA's ERRS contractors were on site on the morning of July 28, 2010 to supplement the containment and oil recovery operations being performed by Enbridge. Gross oil recovery activities were implemented during this time period with a focus on immediate containment and recovery of free oil. Containment and recovery response activities were conducted at the best recovery locations available until more suitable locations were located.

To manage the growing response, the UC Planning and Operations Sections divided the site into five geographical response areas, Divisions A through E, and waste storage areas.

5.1.1. Division A

Division A was defined as the area immediately adjacent to the location of the pipeline rupture, known as the Source Area (Figure 12). Initial efforts focused on containing free oil at the Source Area. On July 26, 2010 Enbridge response crews began installing containment and barriers to stop the flow of oil into Talmadge Creek. By July 28, 2010 containment and recovery equipment was deployed, including hard boom, soft boom, oil skimmers, vacuum trucks, and frac tanks.

Figure 12 – Recovery Operations at the Source Area (8/2/2010)

Enbridge constructed three earthen berms to isolate the Source Area. Enbridge dug shallow sump collection trenches within the isolation zone between the earthen berms to contain the oil. Enbridge also constructed additional temporary containment berms and associated collection trenches in the Source Area, as necessary, to prevent the migration of oil to Talmadge Creek. The containment berms were constructed of clean on-site soil and granular materials to reduce the potential for subsurface water flow under the berms. Enbridge recovered oil from the collection trenches using skimmer pumps and/or pump trucks. Enbridge built approximately 3 mi of roadways into the Source Area using swamp mats to allow access for vacuum trucks and other heavy equipment. Initially, Enbridge excavated oil-saturated soil within Division A based on visual observation of visible gross oil and/or the presence of rainbow sheen emanating from the soils.

A sheet pile trench box was constructed in the Source Area, immediately parallel to the ruptured pipeline. At approximately 180 ft in length, this trench box allowed for dewatering and access to the pipeline. A portion of the pipeline was exposed for 50 ft on either side of the failed pipe joint to examine for corrosion, coating condition, or other issues. Following inspection, a 50-foot length of pipe, which included the ruptured portion, was removed and shipped to NTSB's Materials Laboratory. Under direction of PHMSA, Enbridge installed 51 ft of new pipe to repair the failed section. The trench box was removed following completion of pipeline repair, product recovery, and soil removal activities. The area was then backfilled.

Silt fencing, flow control structures, and other engineered devices were used for stormwater management around construction areas within the Source Area. Enbridge submitted a preliminary joint permit application to MDEQ for stormwater discharge and erosion control during recovery and removal activities.

5.1.2. Division B

Division B was defined from Talmadge Creek, immediately adjacent to the Source Area, to the confluence of Talmadge Creek with the Kalamazoo River.

Containment boom was installed at various access points within Division B (Figure 13) to contain and direct surface oil to accessible collection points. Additionally, Enbridge constructed a flume system consisting of a series of inverted weirs in Talmadge Creek. Drum skimmers and/or vacuum trucks recovered oil from the collection points and flume system. Recovered oil was transported to Frac Tank City, the frac tank staging area discussed in Section 4.6.3, and offloaded to frac tanks for temporary storage.

Figure 13 – Recovery Actions and Devices at Talmadge Creek (8/2/2010)

Enbridge deployed absorbent boom along Talmadge Creek from the Source Area to the confluence with the Kalamazoo River. Additionally, Enbridge placed the absorbent boom along shoreline to collect oil leaching from the creek banks and perpendicular to flow to form cells. Teams used sorbent pads to collect surface oil within each cell.

The UC placed an early and heavy emphasis on containment and recovery at the confluence of Talmadge Creek with the Kalamazoo River. A variety of booming configurations were utilized, consisting of hard boom for containment and absorbent boom for surface oil recovery. The sorbent boom was used both inside and outside of containment boom. Inside the containment boom, sorbent boom was used to collect free oil, while sorbent boom outside of containment boom was used to capture oil that escaped containment boom. Boom maintenance crews continually monitored the condition and effectiveness of the booms. In addition to sorbent boom, bulk oil was collected with drum skimmers and/or vacuum trucks and transported to Frac Tank City for temporary storage.

In addition to the booming strategies, Enbridge constructed an underflow dam upstream of the confluence. Water passed through the submerged corrugated pipe inlet, while pooled surface oil was contained behind the dam for collection using sorbent boom, pads, and drum skimmers.

Later, Enbridge constructed a sedimentation trap immediately upstream of the confluence to create reduced flow and enhanced depositional conditions for collection of affected oily sediment. Maintenance crews continually monitored the trap for sediment and oil deposition. Vacuum trucks were used to remove oil and oil-affected sediment from the trap.

Silt fencing and coconut coir logs, consisting of densely packed coconut fibers covered in mesh netting, were installed on both sides of the creek for erosion control during the early response activities.

Enbridge excavated free oil from the banks of Talmadge Creek within Divisions A and B (Figure 14), in accordance with the approved Source Area Response Plan (Enbridge, 2010). Divisions A and B were each divided into 10 sections. Each section was divided into approximately 10 subsections 50 linear feet in length and designated with stationing on the left and right creek banks. Following clearing of trees and vegetation, timber mat access roads were constructed along the entire reach of Talmadge Creek to allow access to construction equipment during bank removal activities.

Long-stick excavators removed bulk oil and affected soil from the creek banks. The vertical limit of excavation was based on the presence of visible bulk oil. Once bulk oil was not visible, a static sheen test was performed to determine if remaining soils produced sheen. Once sheen was not readily observed emanating from the soil, a test pit was constructed. If free oil was observed in the test pit after six hours, additional excavation commenced. If free oil was not observed after six hours, excavation was complete and the banks were backfilled. Alternatively, the vertical limit of excavation was reached when teams encountered a silt/clay confining layer or groundwater.

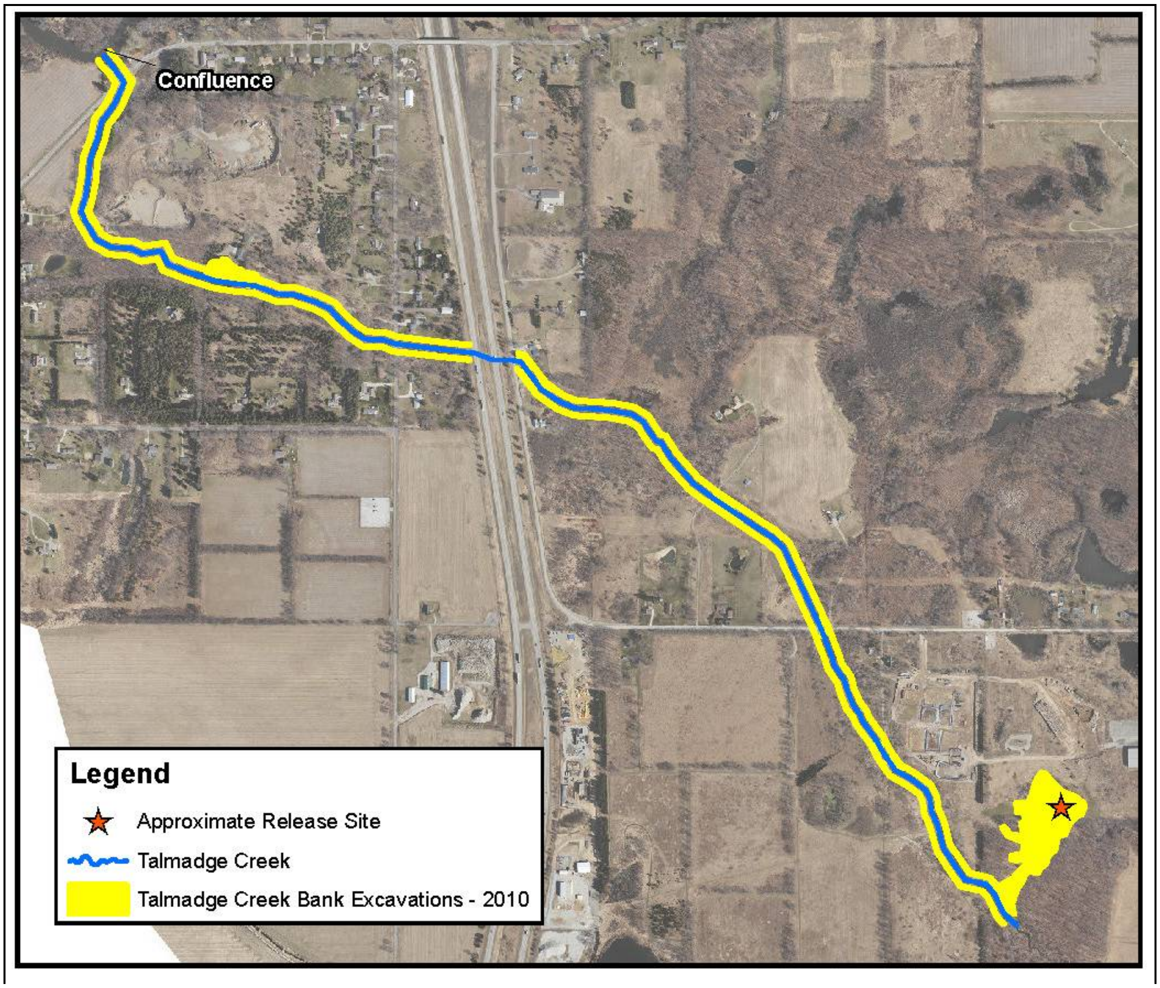
Excavation widths were based on visual observations of free oil and varied from approximately 20 to 125 ft. An observation pit was installed along the wall of the excavation boundary. If oil was observed after 48 hours, an evaluation was conducted to identify the source, and an X-Tex®

curtain (a non-polar, lipophilic, hydrophobic material made from recycled polymer fibers) was installed to separate the affected area from the clean area. Backfilling proceeded after the barrier curtain was installed or if no oil was observed in the pit.

Oil was allowed to drain from excavated soil in staging areas. The staging areas consisted of a series of lined containment berms to prevent stormwater run-off and/or contact with native soils. Oil was recovered and transferred to frac tanks for temporary storage. Contaminated soils were transported to approved off-site disposal facilities. Oil-contaminated soils and/or debris were excavated from approximately 4.7 acres near the Source Area in Division A. Additionally, oil-contaminated soils and/or debris were excavated from approximately 11 acres along Talmadge Creek in Division B.

Following excavation, the banks were reconstructed with imported fill material, seeded, and covered with erosion control jute matting. Coir logs were installed within the creek along the banks to prevent migration of bank soil and sediment from entering the creek. Additionally, silt fencing was installed along the surface of the banks to prevent surface soil migration after precipitation events.

Figure 14 – 2010 Talmadge Creek Banks Excavation



5.1.3. Division C

Division C was defined from the confluence of Talmadge Creek and the Kalamazoo River to the Angell Street Bridge on the west side of Battle Creek.

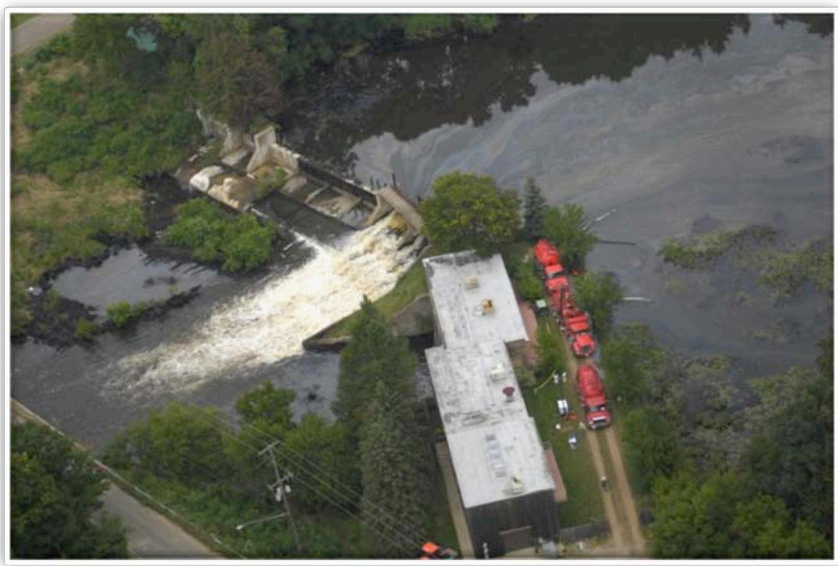
Enbridge deployed containment boom within Division C along the shoreline and at numerous collection points. Hard boom was configured at an angle to direct oil to a shoreline collection point. Drum skimmers and/or vacuum trucks recovered surface oil and water from each collection point. Recovered oil and water were transported in vacuum trucks to Frac Tank City for temporary storage. Attempts to deploy collection boom within the days immediately after the spill were complicated by flooding conditions and resulting high river flow.

Protective containment boom was deployed to isolate backwater areas from the main river channel to minimize oil accumulation within these areas.

Absorbent boom was deployed along the river shoreline and around the islands to prevent oil leaching out of the shoreline from migrating back into the river. Absorbent pads, absorbent sweep, and snare boom were used to recover free oil accumulated within the absorbent booms between the shoreline and the open river. Maintenance crews continually monitored the condition and effectiveness of the boom. Spent absorbent materials were collected for disposal and replaced.

Early response activities in Division C focused heavily on the Ceresco Dam area (Figure 15). The dam structure provided a barrier that slowed the downstream migration of oil; consequently, the upstream impoundment area provided a prime location for oil recovery activities. Several hard boom configurations were constructed to contain surface oil. Multiple vacuum tankers were stationed at Ceresco Dam and operated continuously to collect surface oil and water immediately upstream and downstream of the dam where heavy oil accumulated. Work crews also used flushing hoses to steer surface oil toward the collection and recovery points.

Figure 15 – Vacuum Trucks Collecting Oil at Ceresco Dam (8/27/2010)



Heavy surface oil trapped within the aquatic vegetated shoreline areas was not easily recovered using conventional methods, including boom and skimmers. Much of the oil-affected aquatic vegetation was removed using an aquatic harvesting machine upstream of Ceresco. Recovered heavy oil and aquatic vegetation were either suctioned by vacuum trucks or placed in bags and transported to a temporary staging area for consolidation with other solid wastes, which were then characterized and transported to approved off-site disposal facilities.

Containment measures were also focused upstream of the Battle Creek Dam, immediately downstream of the Mill Ponds. Hard boom was lined with absorbent boom and deployed along the downstream edge of the North Mill Pond to prevent the discharge of heavy oil intermixed with vegetation into the spillway. A control point using a shore-to-shore hard boom coupled with sorbent boom was installed in the main channel to recover surface oil originating from upstream of the South Mill Pond. Shore-to-shore hard boom and sorbent boom were deployed immediately upstream of the culverts leading to the Battle Creek spillway. Additional hard boom was installed at the mouth of the South Mill Pond to block oil from entering the Mill Ponds while concurrently directing surface oil to the collection point immediately downstream.

5.1.4. Division D

Division D was established from the Battle Creek Spillway to the Calhoun County/Kalamazoo County Line. Initial response activities in Division D focused primarily on installation and maintenance of control points at key locations. Control points consisted of shore-to-shore hard boom lined with sorbent boom. Drum skimmers and vacuum trucks were used to recover the oil and oily water accumulated at the collection points.

Figure 16 – Containment Boom in Cascade Configuration in Division D (8/7/2010)

Sorbent boom was deployed along the shoreline and around the river's islands to prevent oil leaching out of the shoreline from migrating back into the river. Sorbent pads, sorbent sweeps, and snare booms were also used to recover free oil accumulated within the sorbent booms between the shoreline and the river channel. Figure 16 shows cascading boom.

Sorbent snare boom was attached and spaced along the hard booms to recover surface oil that accumulated within hard booms. Installation of an array of snare boom within weighted gabion baskets that were strategically placed in the river allowed additional recovery of both surface oil and oil entrained within the water column.

Air curtains were installed in several locations in an effort to push oil entrained within the water column to the surface for collection.

5.1.5. Division E

Division E was established from the Calhoun County/Kalamazoo County Line to the Morrow Lake Dam. Initial containment boom deployed within Division E included several control points with shore-to-shore hard boom lined with sorbent boom. Drum skimmers and vacuum trucks were used to recover the oil and oily water accumulated at the collection points.

Sorbent boom was deployed along the river shoreline and around the islands, particularly in the Morrow Lake Delta, to prevent oil from leaching out of the islands and shoreline and migrating back into the river channels. Sorbent pads, as well as sorbent sweeps and snare booms, were used to recover free oil accumulated within the sorbent booms between the shoreline and river channel.

Figure 17 – Double Chevron Boom Upstream of Morrow Lake Dam (8/14/2010)

Installation of an array of snare boom within weighted gabion baskets that were strategically placed in the river allowed additional recovery of both surface oil and oil entrained within the water. One air curtain was installed directly upstream of the Morrow Lake Delta to push oil entrained within the water column to the surface for collection.

Although initial visual observations did not identify surface oil at the Morrow Lake Dam, a double chevron containment boom configuration was installed as a precautionary measure to ensure surface oil did not migrate beyond the Morrow Lake Dam (Figure 17).

5.1.6. Initial Submerged Oil Containment and Recovery

Within the first weeks of the response efforts, EPA began to evaluate the potential for some of the discharged oil (diluted bitumen) to become submerged within the Kalamazoo River system. As the lighter, diluent fractions of the discharged oil volatilized, the density of the oil increased. Additionally, turbulent water conditions resulting from the flood event and recovery operations (i.e. boat traffic, collection activities, etc.) caused the oil to mix with sediments and organic particles, further increasing its density. As a result, the oil submerged, deposited into the river sediments, and moved through the river system below the surface of the water.

Submerged oil was first observed when personnel from the Wildlife Section reported stepping out of boats and into shallow sediments and producing oil globules and heavy sheen from the sediments. Subsequently, Enbridge proposed the aforementioned method of poling to determine if oil was present in and/or on sediment in areas absent of oil sheen and/or globules on the water surface.

Existing structures, such as dams, and natural barriers, such as islands and sand bars, created preferential depositional areas for submerged oil to accumulate within the river system.

Figure 18 – Gabion Basket in the Kalamazoo River (1/28/2012)

During the initial response actions, various anthropogenic structures (i.e., silt curtains, gabion baskets, and a sediment basin) were placed in the river and along Talmadge Creek in an attempt to contain submerged oil and/or oil-containing sediment from further migration. Like the natural structures, these installed structures created preferential depositional areas in the river system. Several subsurface containment structures were installed within the affected portion of Talmadge Creek and the Kalamazoo River, including:

- underflow dams and hay bale structures at various locations within Talmadge Creek,
- an in-situ stream sediment basin upstream of the confluence of Talmadge Creek with the Kalamazoo River,
- surface boom with sediment curtain at the confluence of Talmadge Creek with the Kalamazoo River,
- gabion basket structures (Figure 18) containing sorbent snare boom at two locations across portions of the river (MP 12.5 and MP 18) to contain suspended oil-containing sediment and submerged oil,
- surface containment with silt curtain installed at numerous control points along the Kalamazoo River, and
- surface boom with X-Tex® sediment curtain (oleophilic synthetic filtering material designed to sorb oil while allowing water to pass through) in the neck area between the Morrow Lake Delta and Morrow Lake.

Structures were routinely monitored and maintained, and subsurface containment materials were replaced.

5.1.7. FOSC Commentary on the Effectiveness of Initial Response Activities

Air Quality: Immediate implementation of air monitoring, sampling, and coordination with public health agencies was paramount to the protection of public health in the wake of the discharge. The discharge of hundreds of thousands of gallons of oil-containing volatile organics such as benzene with the potential for public health impact and worker safety risk demanded the highest priority – even as operations personnel were still working to identify the extent of the spill and to contain it. Early public health decisions regarding evacuations and exposures relied upon rapid generation of near real-time monitoring data. The implementation of 24-hour air sampling continued to guide ongoing public health and occupational exposure evaluations to ensure that the general public and workers involved in cleanup were not exposed to harmful levels of air contaminants related to the spill.

Conventional Containment and Recovery: Within just a few weeks from the date of the discharge, use of conventional oil spill response strategy, tactics, and equipment (booming, skimming, vacuuming, and excavation) resulted in the recovery of over 760,000 gallons of floating oil or oil soaked into overbank areas of the Talmadge Creek and Kalamazoo River. Thus, while it was immediately recognized that weathering of the diluted bitumen was resulting in its submergence, it was also demonstrated that the submergence characteristic did not arise immediately, and timely application of standard, conventional floating oil recovery principles and methods was extremely successful.

Early Submerged Oil Containment: At the same time, based on EPA’s experience during this response, EPA recognizes that submerged oil should be immediately and aggressively contained. Use of sediment curtains, X-Tex® curtains, gabion baskets, and air curtains all demonstrated some level of effectiveness in containing submerged oil early in the response. The gabion basket setup containing sorbent snare boom was one of the most effective methods employed early in the response. EPA learned that the placement of gabion basket structures in areas where flow velocities were less than one foot/second was most effective in the collection of submerged oil. Placing such structures in higher velocity areas resulted in significant scouring of the river bed sediment, resulting in less effective capture of submerged oil. Additionally, the use of closed loop snare within the gabion basket structures resulted in more effective capture of submerged oil particles. Sediment curtains made with X-Tex® material were more effective in absorbing submerged oil than traditional sediment curtain. As with the gabion baskets, placement of X-Tex® sediment curtain in low velocity areas is crucial to keeping the curtain on the sediment bed. During subsequent stages of the response, EPA recognized that development of methods to deploy X-Tex® sediment curtain in higher flow areas would be beneficial in curtailing further migration of submerged oil in areas such as the Morrow Lake Delta neck. Development of the half-curtain or partial curtain deployment technique proved beneficial in limiting further migration while maintaining the curtain along the river bottom in higher flow velocity areas. Use of the air curtain techniques attempted early in the response seemed to be the least effective of the early submerged oil containment methods employed.

Earlier implementation of final endpoint strategy of collection of submerged oil in sediment traps and impoundments by dredging may have been possible if efforts to concentrate it in areas amenable to these methods of submerged oil containment had been strategically implemented more broadly and with greater intensity earlier. Also, the submerged oil containment concepts of half curtain/boom deployments developed and implemented in 2013 and 2014 to control submerged oil migration in the Morrow Lake Delta were determined to be very effective and warrant strong consideration for earlier, broader deployment during future discharge events.

Finally, while much innovation in submerged oil response occurred during the cleanup, there exists a great need for ongoing research and development into effective submerged oil containment devices and tactics.

5.2. Submerged Oil Assessment and Recovery

5.2.1. 2010 Qualitative and Quantitative Submerged Oil Assessment

On August 24, 2010 the Submerged Oil Task Force (SOTF) was created to perform field assessment, characterization, and mapping of submerged oil in surface water and sediments of Talmadge Creek, the Kalamazoo River, and Morrow Lake. The work scope of the SOTF was later expanded to include preparing recommendations for oil recovery based on the field assessment and ecological assessment data. The SOTF was comprised of representatives from EPA, MDNR, and Enbridge.

Figure 19 – Submerged Oil Task Force Poling Team, Kalamazoo River (9/26/2010)

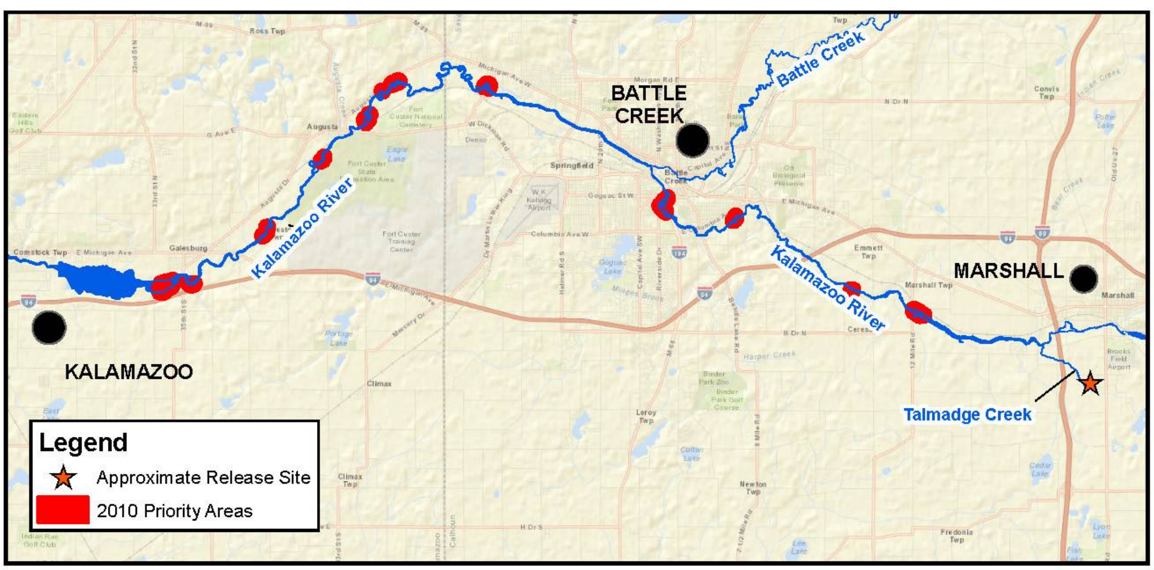
A phased approach was implemented to investigate the presence and relative distribution of submerged oil in the Kalamazoo River and Morrow Lake. Initially, a qualitative assessment was conducted to quickly identify areas with the presence of submerged oil, identify depositional areas, prioritize sites based on a relative comparison of affected sites, and obtain information on the depositional/erosional characteristics of the geomorphic settings. This was accomplished through an initial visual assessment followed by in-channel sediment poling (Figure 19). Poling is a method that has been used in other affected river systems. Determining parameters by which to record observations from poling was essential to ensure that poling results were evaluated and recorded consistently.

Poling involved inserting a graduated metal pole equipped with a disk into the sediment and then recording observations. Observations included depth to soft sediment (i.e., first contact with subsurface resistance), estimated thickness of soft sediment (determined through additional pushes of the poling device with more force), and oil/sheen manifestation on the water surface. Teams recorded visual evidence of oil as it was liberated from the sediment and rose to the water surface. A uniform set of metrics was used to evaluate the emanating oil and included the number of oil globules and areal sheen production in a one-meter square surrounding the poling location. Teams also documented the Global Positioning System (GPS) coordinates, water surface elevation, and depth of water. Approximately 3,700 discrete points were collected from August 29 through October 29, 2010. Poling procedures in 2011 were amended to include documentation of water and sediment temperature as well.

The SOTF recognized the potential influence of natural depositional areas within the Kalamazoo River, including oxbows, islands, and sandbars, as sites of accumulation of submerged oil. These features were mapped and used to identify appropriate sampling locations during the following quantitative assessment phase. The visual presence of oil identified during the prior qualitative assessment phase was the primary criterion used to prioritize sites for sampling. SCAT data and sediment and water sampling information were used as additional lines of evidence to select the focused sample locations. The quantitative assessment teams collected over 500 sediment cores at depositional locations where submerged oil was observed. The sediment cores were logged (see Section 8.8 for logging procedures) in a field laboratory configured for identifying visible oil present in the sediment. Results of the logging indicated that submerged oil was present in the top four inches of the sediment in the form of globules and/or flakes.

The initial qualitative assessment identified 34 locations that potentially contained significant accumulations of submerged oil. The SOTF further evaluated these 34 sites based on the qualitative and quantitative site assessment data. As a result, 18 sites (Figure 20) were identified as priority locations for permanent oil recovery based on their potential for remobilization of oil from sediment into surface water.

Figure 20 – Priority Locations Between Ceresco Dam and Morrow Lake Delta



5.2.2. 2010 Ecological Assessment

In September 2010 EPA and Enbridge conducted ecological habitat assessments at 27 sites, including the above 18 priority submerged oil locations. These assessments characterized the ecological communities and habitats and helped guide cleanup operations, as discussed in Section 5.2.3. EPA, MDNR, and Enbridge mapped vegetation types at each priority area onto high-resolution aerial photographs on the basis of the dominant genera of plant species present. Teams also recorded water depth and turbidity, bottom substrate, and habitat characteristics including the presence of coarse woody debris, rocks, or other structures affecting the distribution of aquatic and semi-aquatic animals. Four major patterns emerged from grouping areas rated as having significant ecological concerns:

- areas consisting of open water habitat coupled with emergent wetland vegetation and aquatic beds were considered high quality habitat for a variety of species;
- areas consisting of emergent wetland vegetation and aquatic beds were considered sensitive to disturbance because their root systems may have difficulty becoming reestablished once they were disturbed;
- areas where submerged aquatic vegetation beds and emergent vegetation were present were considered for cautious approach so that recovery activities would avoid disturbance to vegetation wherever possible, with oil recovery focused on the channel areas and areas with little or no vegetation; and
- depositional areas in backwaters that were not vegetated were typically surrounded by forest and exhibited low diversity of species and opportunities for fish and wildlife habitat. Short-term disturbances to these areas were not expected to cause significant impacts. However, the recommendation was for operations to be water-based when possible to avoid further impacts to Palustrine Forested Wetland communities.

5.2.3. 2010 Submerged Oil Cleanup Recommendations

While the SOTF was completing assessment activities, the FOSC directed Enbridge to identify and test various field techniques that would be effective at liberating submerged oil from the river sediments so that it could be recovered. Several small-scale field tests, or pilot tests, were conducted at known submerged oil locations to determine which oil recovery techniques were most effective at recovering submerged oil. From the field test program, the following techniques were identified:

- Hydraulic Flushing: Pressurized river water was used to agitate shallow sediment and liberate submerged oil so that it could be recovered at the water surface using sorbent material.
- Aeration: Pressurized air was injected into shallow sediment to liberate submerged oil so that it could be recovered at the water surface using sorbent material.
- Manual Agitation: River sediment was agitated using manual methods, such as raking, to liberate submerged oil so that it could be recovered at the water surface using sorbent material.
- Dredging: Sediment containing submerged oil was mechanically removed.

The SOTF considered the ecological assessment results in conjunction with possible recovery approaches and provided site-specific recommendations to the FOSC at the 18 priority areas. SOTF recommendations were approved by the FOSC prior to implementation. The SOTF identified the nine areas listed in Table 2 as having limited habitat and/or ecological value. The SOTF recommended reasonably aggressive steps be taken to recover the oil, including sediment aeration, sediment skimming, flushing, and/or raking.

Table 2 - Areas of Limited Habitat or Ecological Value

Site	Description	Water depth (ft)
MP 7.75 - Overflow Channel	Small overflow channel on the left descending bank (LDB)	< 1
MP 14.75 - Overflow Channel	Overflow channel on the right descending bank (RDB)	2 to 3
MP 26.0 - Backwater Cove	Backwater pool on the RDB	< 0.5
MP 26.25 - Cutoff Channel	Small cove on the RDB	<1
MP 26.65 – Cove	Small cove on the RDB	< 0.5
MP 27.9 - Meander with Depositional Bar	Small meander with a depositional baron on the RDB	~ 0.5
MP 28.25 – Oxbow	An oxbow on the RDB	< 1
MP 33.0 - A and B - Backwater Channels	Two backwater areas on the LDB and RDB	< 1
MP 33.25 - Backwater Channel	Backwater channel on the RDB with a small island in the center	< 1

The SOTF then identified the three areas listed in Table 3, located in the Ceresco Dam Impoundment, as having high ecological and habitat values. However, the SOTF recommended dredging for these areas because the sediments were heavily oiled and earlier response efforts had already affected the ecological setting of this area.

Table 3 – Areas of High Ecological and Habitat Value at Ceresco Impoundment

Site	Description	Water depth (ft)
MP 5.55 North - Upstream of Ceresco Dam	Shallow cove on the RDB approximately 1,400 ft upstream of Ceresco Dam	0 - 1 near shore, > 2 further from shore
MP 5.63 South - Cove Upstream of Ceresco Dam		
MP 5.75 - Ceresco Dam	Approximately 1000 linear ft of shoreline along the RDB	0.5 to 1.5 near shore, Deeper further from shore

Lastly, the SOTF identified the six areas listed in Table 4 as having high ecological and habitat values. The SOTF recommended that either no action or less aggressive recovery steps be undertaken, such as cautiously raking and flushing to avoid damage to the existing flora and fauna.

Table 4 – Areas of High Ecological and Habitat Value

Site	Description	Water depth (ft)
MP 12.5 – Oxbow	Channel on the RDB	0.5 to 1.5
MP 15.25 - South Mill Pond	Backwater wetland connected hydraulically to the river	0 to 1 in vegetated areas; 1 to 2 in open water
MP 15.5 - North Mill Pond	Backwater wetland connected hydraulically to the river	0 to 1 in vegetated areas; 1 to 2 in open water
MP 21.5 – Oxbow	Open water meander with a constriction that made it depositional along the RDB	0 to 1
MP 36.25 - Cutoff Meander	Backwater channel on the RDB with a small island in the center	< 1
MP 36.5 to 37.5 - Morrow Lake Delta	40 acre delta area on the upstream end of Morrow Lake, consisting of interconnected braided channels and islands	Generally 0 to 1 ft with deeper areas in the channels between islands

After the recovery recommendations were developed for the 18 priority areas, moderate and low priority submerged oil locations identified during refined poling activities were brought to the SOTF for consideration of containment and recovery activities. Site summaries were prepared for the 18 priority areas and the newly identified sites. Once the SOTF concurred with the findings and recommendations and received FOSC approval these new sites were addressed through the recovery of submerged oil and/or oil-containing sediment following the protocols developed in the approved Strategy and Tactics for Permanent Recovery of Submerged Oil and Oil-Contaminated Sediment (Enbridge, 2010).

While Talmadge Creek was not originally included in the SOTF recommendations, field assessments were later conducted along the entire two mi of Talmadge Creek and three areas of submerged oil were identified as candidates for recovery.

5.2.4. 2010 Submerged Oil Recovery

Consistent with the SOTF site-specific recommendations, initial submerged oil recovery consisted of: 1) aeration of submerged oil and/or oil-containing sediment to release the submerged oil to the surface where it was recovered using sorbent material; and 2) oiled-sediment removal via conventional dredging.

Containment was installed at each oil recovery location to minimize downstream migration of oil and/or oil-containing sediment. Immediate, local containment devices, including hard boom, sorbent boom, or geotextile curtains were installed for containment of oil brought to the surface. Sorbent boom was deployed along the entire shore side perimeter of the work area and along any vegetative areas.

Figure 21 – Oil Recovery via Sediment Agitation using River Water (10/16/2010)

Sediment agitation (Figure 21) was performed using a pond aeration unit with an electric motor and aluminum impeller. Teams utilized the aeration unit in cells of approximately 50 ft of linear runs from the shoreline to the containment boom. Oil collection points were established at areas that had the lowest ecological complexity and that were the most accessible. Floating oil was directed to the collection points by leaf blowers for collection by sorbent materials, including pads, mops, and pom-poms. Aeration and collection continued until there was no visible oil present on the water surface.

Following a two-day rest period to allow for site conditions to settle, EPA and Enbridge inspected a recovery site to determine whether visible oil was present. A post-sediment aeration assessment was performed following the same procedures used for initial site assessment. The SOTF compared the initial and post-recovery results to determine the effectiveness of the submerged oil recovery effort.

When the aeration method could not be used due to insufficient water depth or based on the SOTF cleanup recommendations, the oil recovery locations were manually flushed with a high-volume, low-pressure water stream; manually raked; mechanically raked; or manually swept. These processes were repeated until there was no visible oil released from the cell. The agitation techniques used at each of the 18 priority locations are listed in Table 5.

Table 5 – Agitation Techniques Used at the 18 Priority Locations of Submerged Oil

Site	Agitation Techniques
MP 7.75 - Overflow Channel	Pond aerators, manual raking
MP 14.75 - Overflow Channel	Pond aerators, manual raking
MP 26.0 - Backwater Cove	Pond aerators, flushing water wands, manual raking
MP 26.25 - Cutoff Channel	Pond aerators, flushing water wands, manual raking
MP 26.65 – Cove	Pond aerators, flushing water wands, manual raking
MP 27.9 - Meander with Depositional Bar	Flushing water wands
MP 28.25 – Oxbow	Pond aerators, flushing water wands, manual raking
MP 33.0 - A and B - Backwater Channels	Pond aerators, manual raking
MP 33.25 - Backwater Channel	Pond aerators, manual raking

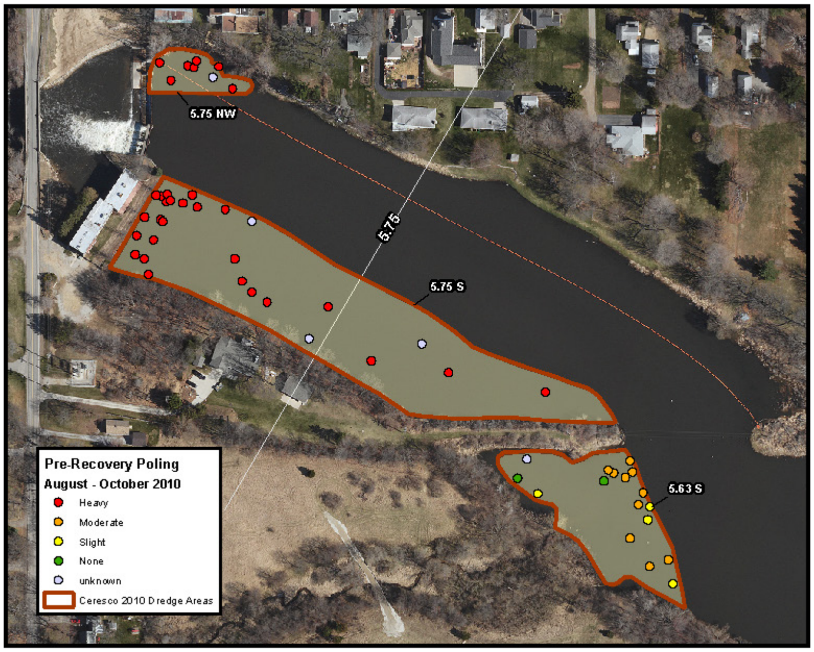
Site	Agitation Techniques
MP 5.55 North - Upstream of Ceresco Dam	Pond aerators, flushing water wands
MP 5.63 South - Cove Upstream of Ceresco Dam	Amphibex dredge technology
MP 5.75 - Ceresco Dam	Amphibex dredge technology, pond aerators, flushing water wands, manual sweeping methods
MP 12.5 – Oxbow	Flushing water wands, manual raking
MP 15.25 - South Mill Pond	Pond aerators, flushing water wands, manual raking
MP 15.5 - North Mill Pond	Pond aerators, flushing water wands, manual raking
MP 21.5 – Oxbow	Pond aerators, flushing water wands, manual raking
MP 36.25 - Cutoff Meander	Pond aerators manual raking
MP 36.5 to 37.5 - Morrow Lake Delta	Pond aerators, flushing water wands, manual raking

Figure 22 –Dredging at MP 5.75 Ceresco Impoundment (9/30/2010)

Because the Ceresco Impoundment was the first major deposition location in the flow path of the released oil, it was the first location where a substantial amount of submerged oil was present where it could be readily removed via dredging. As a result, Enbridge dredged submerged oil and/or oil-containing sediment at priority locations within the Ceresco Dam Impoundment, immediately upstream and downstream of the former train trestles. Dredging was performed using an Amphibex dredge, which integrated a hydraulic cutterhead dredge with a positive-displacement pump (Figure 22). In addition to the Amphibex, two other dredges were used to supplement its production. A smaller dredge was used at MP 5.63 South and a cutterhead dredge was used in the deeper waters of MP 5.75 Northwest.

The primary dredge area was MP 5.75 South, located along the left descending bank of the Kalamazoo River from Ceresco Dam to approximately 900 ft upstream of the dam, with a width of approximately 200 ft. Additionally, dredging was completed at MP 5.63 and MP 5.75 Northwest. The overall dredging footprint was approximately six acres in size. The majority of the footprint was dredged to a depth of approximately one to 1.5 ft. Approximately two ft of material were removed close to the face of Ceresco Dam. A total of 6,800 cubic yards of contaminated sediment was removed. As evidenced by the 2010 pre-dredge (Figure 23) and post-dredge (Figure 24) poling results at Ceresco, removal of submerged oil via dredging resulted in a greatly reduced submerged oil footprint.

Figure 23 – 2010 Pre-Dredging Poling Results (Ceresco Impoundment)

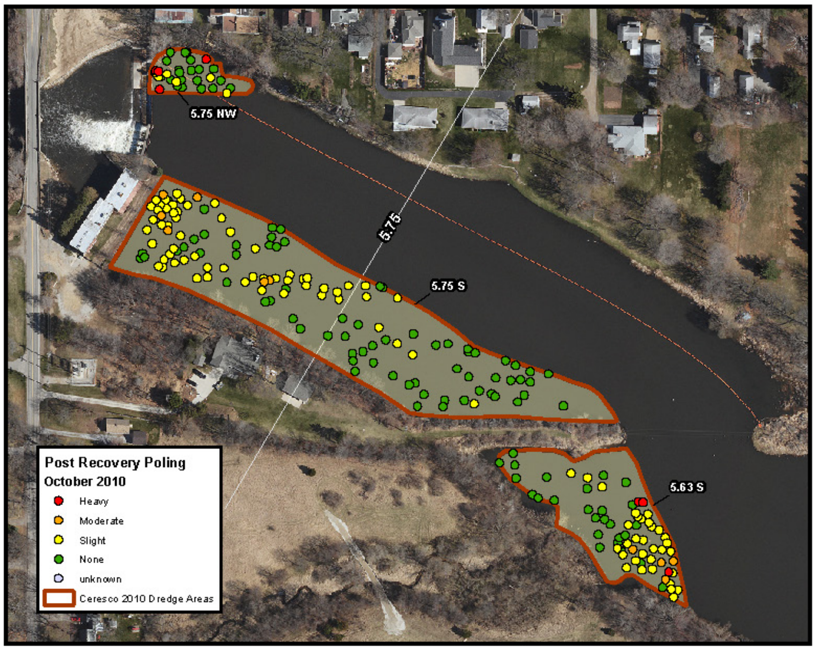


Continuous, real-time surface water quality measurements were performed at locations downstream and upstream of dredging operations. Teams monitored turbidity, pH, dissolved oxygen, specific conductivity, and temperature. Turbidity measurements were successfully used as part of the best management practices to ensure that dredging operations did not create sustained periods of downstream turbidity greater than two times upstream levels. If turbidity levels exceeded the actionable threshold, then dredging operations were temporarily halted and containment inspected/revised to minimize the downstream migration of turbidity plumes. The placement and maintenance of containment boom and turbidity curtains successfully contained sheen and turbidity within the dredge area.

Surface water samples were collected daily at locations upstream of dredging operations, downstream of operations but upstream of Ceresco Dam, and downstream of Ceresco Dam immediately west of the final containment devices. Analytical results indicated that volatile organic compound (VOC) and semi-VOC concentrations were below the reporting detection limit. Relatively minor concentrations of iron, lead, zinc, and manganese were detected sporadically during the sampling program at three locations. The results demonstrated that surface water quality was not adversely affected by dredging operations.

Real-time air monitoring and air sampling were conducted before and during the Ceresco dredging operations. Air monitoring results documented two benzene detections out of approximately 2,240 readings, and 16 VOC detections out of approximately 5,770 readings. The maximum concentration was one ppm for benzene and 0.9 ppm for VOCs. The majority of analytical sample results indicated that no oil-related analytes were detected. These air monitoring and sample results confirm that air quality was not adversely affected by dredging activities. Additionally, no odor complaints were reported as a result of dredging operations.

Figure 24 – 2010 Post-Dredging Poling Results (Ceresco Impoundment)



5.2.5. Spring 2011 Submerged Oil Reassessment

On March 7, 2011 the FOSC directed Enbridge to reassess the Source Area, Talmadge Creek, the Kalamazoo River, the Morrow Lake Delta, and Morrow Lake to identify locations of oil sheen and/or globules that could continue to threaten navigable waterways. The affected system was reassessed in April and May 2011, in accordance with the approved Overbank and Poling Reassessment Work Plan (Enbridge, 2011a). Reassessment results were used to assess the distribution and relative degree of submerged oil presence in the system, assess the change in distribution as compared to 2010, and rank and prioritize areas for recovery actions.

The Spring 2011 Submerged Oil Reassessment relied on the poling technique to determine the locations and relative degrees of submerged oil presence. Poling teams manually agitated soft sediment using a pole with an attached disk. Agitation liberated submerged oil from the sediment, allowing it to rise to the water surface in the form of oil sheen or globules. A team, composed of mostly Enbridge personnel with oversight and direction from EPA and MDEQ, used the Submerged Oil Field Observation Flowchart, shown in Figure 25, to categorize the response of the submerged oil to poling at each location as heavy (Figure 26), moderate, light, or none. Teams also recorded the GPS coordinates, depth from the water surface to top of sediment, soft sediment thickness, and the channel bed type at each poling location. All poling was conducted when water and sediment temperatures were at a minimum of 45 °F.

Figure 25 – Submerged Oil Field Observation Flow Chart

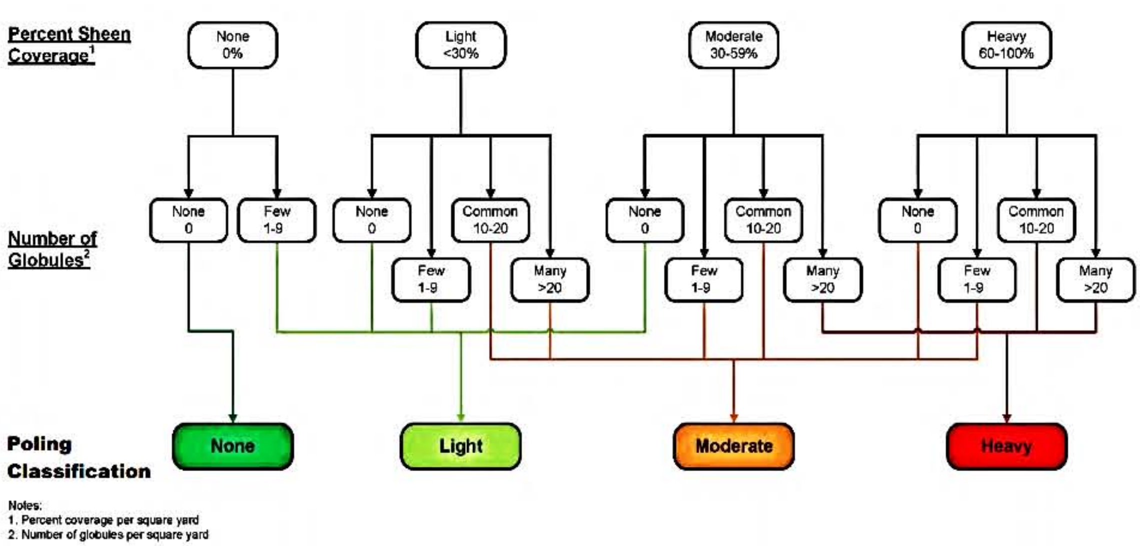
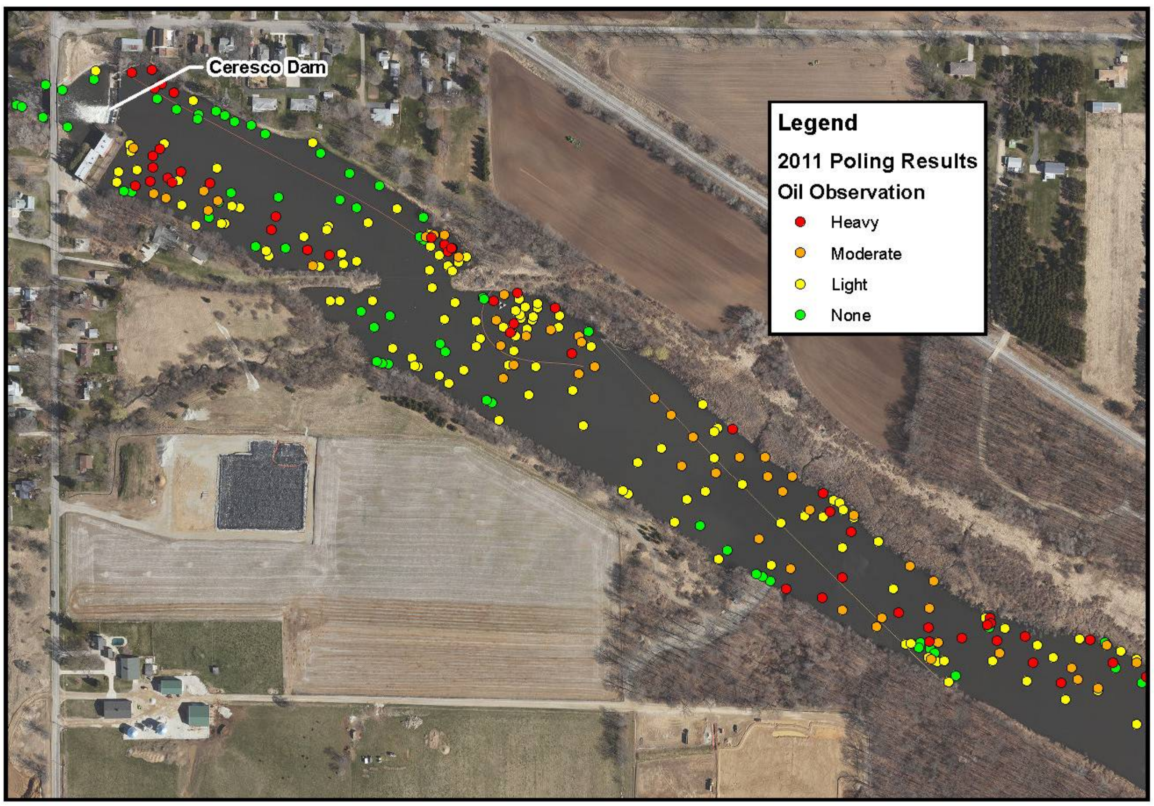


Figure 26 – 'Heavy' Sheen Observed During Poling of a Submerged Oil Location (5/11/2011)

Reassessment poling activities focused on areas confirmed in 2010 to have 'heavy' and/or 'moderate' submerged oil accumulations and in areas in which submerged oil was expected to accumulate based on interpretation of geomorphic data. In addition, poling was conducted along transects that were perpendicular to channel orientation in low- and high-sinuosity sections of the river, near bridges and other public access areas, and in low gradient areas upstream of dams.

Data from the individual poling locations were mapped and used to create Geographic Information System (GIS) polygons, depicting areas of submerged oil deposits. As a result, 223 submerged oil locations were identified between the confluence of Talmadge Creek with the Kalamazoo River and the Morrow Lake Dam. These areas represented a cumulative total footprint size of nearly 180 acres. Areas of heavy' and/or moderate submerged oil were primarily located in low gradient areas and geomorphic depositional areas where velocity was significantly reduced (i.e., inside meanders, cut-off channels, oxbows, and backwaters). The primary submerged oil depositional areas included Talmadge Creek, upstream of Ceresco Dam (Figure 27), upstream of the Kalamazoo River Dam, the oxbow at MP 21.5, and the Morrow Lake Delta/Fan. This submerged oil configuration was believed to represent the river's consolidation of more diffuse pockets of submerged oil since the fall of 2010.

Figure 27 – Spring 2011 Submerged Oil Reassessment Results at Ceresco Impoundment



Results of the Spring 2011 Submerged Oil Reassessment also indicated that submerged oil was transported downstream during a May 2011 flood event. Evidence of this migration was found in the redeposition of submerged oil at Ceresco Dam after the 2010 recovery activities and the identification of nearly 90 acres of submerged oil in the Morrow Lake Fan area that was not present in the fall of 2010.

5.2.6. Spring 2011 Overbank Strike Site Reassessment

During the 2011 Shoreline and Overbank Reassessment, to be discussed in Section 5.4.2, numerous overbank areas could not be reassessed through the Shoreline and Overbank Reassessment (SORT) process because they contained ponded water. Specialized overbank strike teams performed submerged oil poling on these areas. Reassessment activities identified 33 locations of moderate submerged oil and 24 locations of heavy submerged oil. The total area of heavy/moderate submerged oil footprint contained within these strike sites was approximately 12.5 acres.

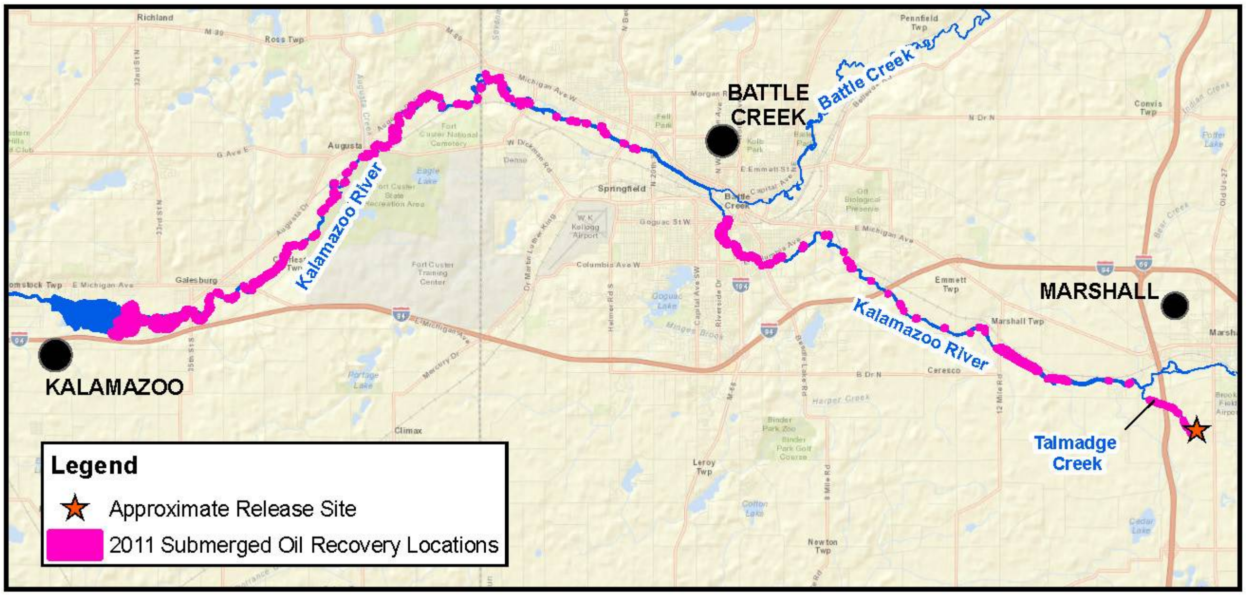
5.2.7. 2011 Submerged Oil Recovery – Agitation

On June 17, 2011 the FOSC directed Enbridge to perform recovery of submerged oil, oil sheen, and oil-containing soils and sediments. Sediment agitation techniques were used to liberate submerged oil from the sediment and bring it to the water surface for recovery. Agitation techniques, or tool box techniques, included manual rakes, handheld tillers, handheld stingers, rotating stingers, vessel-mounted water injectors, vessel-mounted pipe drags, and hydraulic flushing (Figure 28). Oil released to the surface was recovered using sorbent materials including booms, pads, and snares. The agitation and recovery process was repeated until no oil was visibly released from the area. Prior to implementation, pilot studies were conducted for each tool box technique to evaluate its effectiveness. Pilot study results were submitted for review and approval by EPA and MDEQ.

Figure 28 – Excavator with Hydraulic Spray Bar Agitating Sediment (7/28/2011)

Tool box agitation and recovery were employed concurrently at each of the major depositional areas, including the confluence of Talmadge Creek with the Kalamazoo River to Ceresco Dam, Ceresco Dam to the Battle Creek Spillway, and the Battle Creek Spillway to Morrow Lake Delta/Fan. This approach was conducted in an upstream to downstream direction within each major river segment. Under direction of the FOSC, submerged oil recovery efforts ceased for the year as of October 28, 2011 due to low water/sediment temperatures. Recovery operations were completed at 191 locations (Figure 29) throughout the affected system in 2011.

Figure 29 – Submerged Oil Locations (2011) Along the Affected Waterways

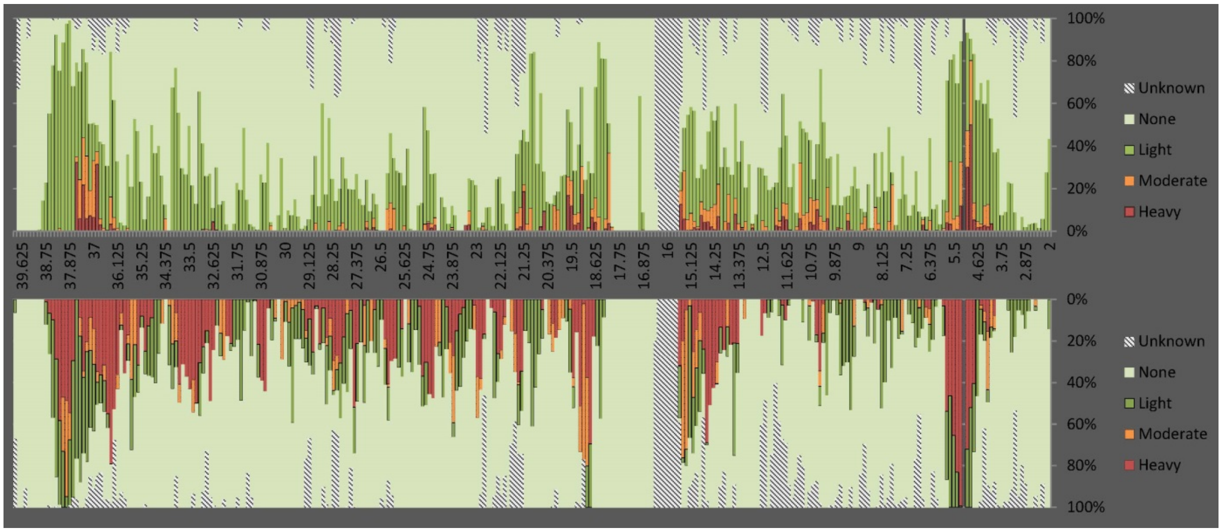


5.2.8. 2011 Late Summer Submerged Oil Reassessment (LSR)

The 2011 Late Summer Submerged Oil Reassessment (2011 LSR) was conducted from August through October 2011 to define the remaining submerged oil areas and to assess the effectiveness of the agitation tool box recovery operations conducted in 2011. Poling was conducted at 4,957 locations throughout the river. Poling data were used to define 233 submerged oil areas, including 103 areas of heavy submerged oil and 129 areas of moderate submerged oil. Poling was conducted when water and sediment temperatures were at a minimum of 45 °F.

Results of the 2011 LSR generally showed a decrease in heavy and moderate submerged oil by area throughout the system, as compared to the Spring 2011 Submerged Oil Reassessment data, as shown in Figure 30. Only 25% of poling locations immediately upstream of Ceresco Dam, from MP 5.35 to MP 5.85, were classified as heavy or moderate; however, several areas between MP 4.5 and MP 5.25 still had moderate and heavy poling designations from bank to bank. Additionally, only a few areas in the Mill Ponds impoundment showed moderate or heavy poling results, outside of the North and South Mill Ponds.

Figure 30 - Submerged Oil Distribution Histogram (2011 LSR – Top; 2011 Spring – Bottom)



5.2.9. Evaluation of the Minimum Poling Temperature

Prior to the 2012 Spring Submerged Oil Reassessment activities, the FOSC recognized the need for enhanced understanding of the effects that temperature had on submerged oil liberation and the effectiveness of recovery methods. It was generally understood that as water temperature decreased, the amount of oil released to the water surface decreased. Therefore, a minimum water temperature of 45 °F, as recommended by Enbridge, was a prerequisite for poling activities.

In accordance with the approved 2012 Consolidated Work Plan (Enbridge, 2011a), Enbridge conducted a temperature effects study to assess the relationship between water temperature and the liberation of submerged oil from sediment. The temperature effects study consisted of a Temperature Effect Monitoring (TEM) study at nine field locations within the Kalamazoo River and a bench-scale study in a controlled laboratory environment. Both study components were conducted for a range of temperatures to determine the optimal minimum temperature for conducting poling activities.

The results of the TEM study suggested a minimum temperature of 55 °F; however, the limited temperature range of the study did not fully support this conclusion. The results of the bench scale study suggested an optimal temperature range from 55 °F to 65 °F.

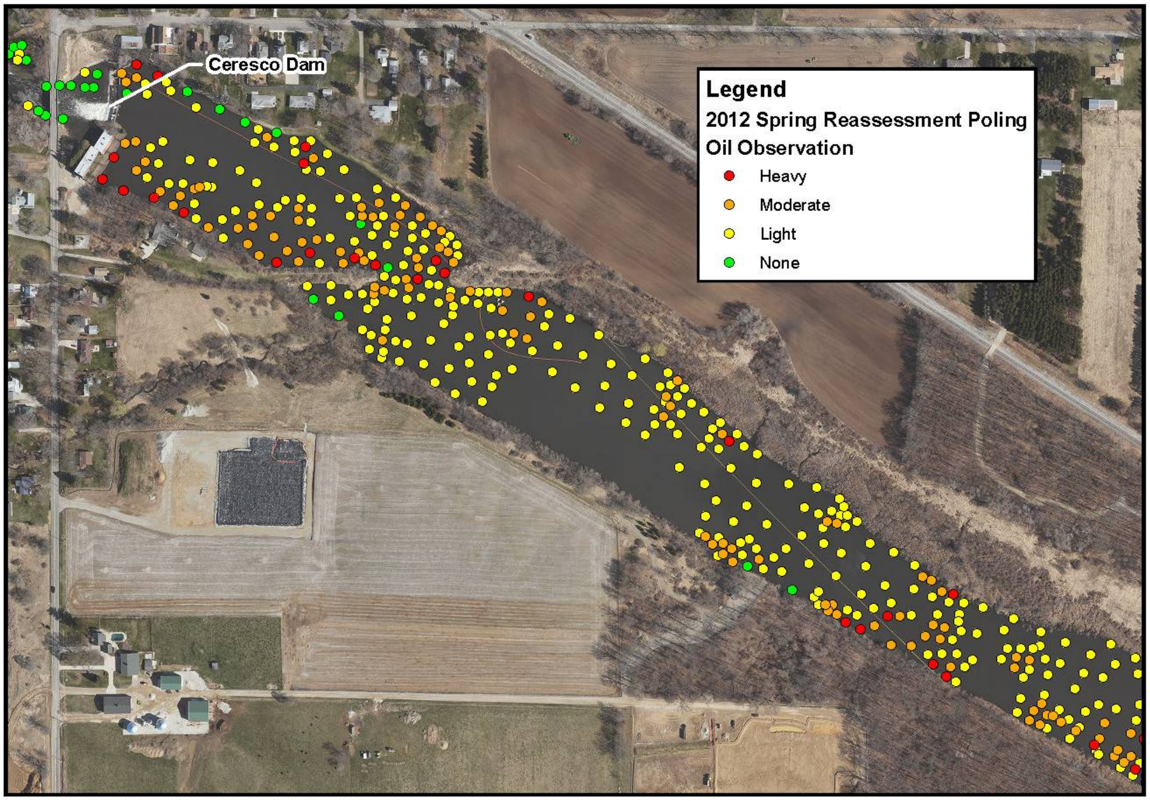
After reviewing the results, the FOSC directed Enbridge to incorporate a minimum water temperature of 60 °F as one of the conditions required to perform future submerged oil assessment via poling. All subsequent reassessment poling was conducted using this minimum temperature.

5.2.10. Spring 2012 Submerged Oil Reassessment

In accordance with the 2012 Consolidated Work Plan (Enbridge, 2011a), Enbridge performed a submerged oil reassessment between the confluence of Talmadge Creek with the Kalamazoo River and Morrow Lake Dam to identify remaining heavy, moderate, and light submerged oil areas in the system. Spring 2012 Submerged Oil Reassessment poling work was conducted in

May and June 2012, with poling at 7,707 locations. The results (Figure 31) showed 3,379 light locations, 1,263 moderate locations and 568 heavy locations. Poling was completed at a minimum water and sediment temperature of 60 °F.

Figure 31 – Spring 2012 Submerged Oil Reassesment Results at Ceresco Impoundment



Results of the Spring 2012 Submerged Oil Reassessment indicated that MP 4.5 to MP 5.0 no longer had any bank to bank moderate or heavy designations and that overall there were fewer moderate or heavy designations as compared to 2011 LSR. Yet, MP 5.0 to MP 5.85 demonstrated a substantial increase in locations classified as 'moderate' or 'heavy.' The relative patterns demonstrated by two rounds of poling in the same locations, which had just undergone extensive recovery actions, were reliable evidence that submerged oil had migrated downstream.

Results also indicated that areas of moderate and heavy submerged oil increased significantly in the Mill Ponds since the 2011 LSR, particularly in areas near the main channel outside the North and South Mill Ponds. These results indicated that submerged oil accumulated in depositional areas along the Mill Ponds between the fall of 2011 and the spring of 2012.

Between the 2011 LSR and the Spring 2012 Reassessment, the footprint of submerged oil expanded to cover the majority of the two mi length of Morrow Lake, downstream of the Delta. Light poling locations extended further west into Morrow Lake, representing roughly 325 acres of light submerged oil downstream of the former Control Point E4.5, compared to approximately 189 acres identified during the 2011 LSR. This substantial expansion occurred during increased river flow conditions.

5.2.11. 2012 Recovery

The 2012 submerged oil recovery strategy involved installation of sediment traps in natural accumulation areas of the Kalamazoo River. Residual oil migrated to the depositional areas through natural transport mechanisms. This strategy allowed for the use of less intrusive recovery techniques as compared to the tool box recovery techniques used throughout 2011 and minimized the ecological impact of recovery. The Sediment Trap Program is discussed in Section 5.7.

Active oil recovery was conducted only through sheen management. Sheen collection boats responded to observations of oil sheen and tar globules throughout the river and collected the oil utilizing sorbent material. This Emerging Oil Management Program is discussed in Section 5.8.

5.2.12. 2012 Late Summer Submerged Oil Reassessment (LSR)

In August and September of 2012, Enbridge conducted the 2012 Late Summer Reassessment (2012 LSR) to define the submerged oil areas throughout affected river system. The 2012 LSR focused on the Ceresco and Mill Ponds impoundments and areas where the moderate and/or heavy submerged oil footprint had increased between the 2011 LSR and the Spring 2012 Reassessment. Poling was conducted 824 locations with 17 target areas on the Kalamazoo River. The results showed 406 light locations, 238 moderate locations, and 87 heavy locations. 2012 LSR poling was not conducted in the Morrow Lake Delta or Morrow Lake because those areas were monitored monthly, pursuant to the Morrow Lake Delta and Morrow Lake Monitoring and Management Work Plan (Enbridge, 2012a), as discussed in Section 5.5.

Results of the 2012 LSR confirmed that the three major impoundment areas of the Kalamazoo River (Ceresco, the Mill Ponds, and the Morrow Lake Delta) contained recoverable accumulations of submerged oil that threatened to migrate further downstream during high river flow events. The 2012 LSR results showed an increased accumulation and footprint of submerged oil between MP 4.75 and Ceresco Dam, as compared to the Spring 2012 Submerged Oil Reassessment. The heavy and/or moderate submerged oil footprint increased from approximately 20 acres during the Spring 2012 Submerged Oil Reassessment to 23.5 acres during 2012 LSR.

The general patterns of heavy and/or moderate submerged oil accumulations in the Mill Ponds were comparable when evaluating the Spring 2012 Submerged Oil Reassessment and 2012 LSR results. However, a direct comparison of the accumulation areas could not be performed due to differences in the monitoring and assessment limitations and data sets. Increased submerged oil accumulation was observed during the monitoring performed between the 2011 LSR and 2012 LSR.

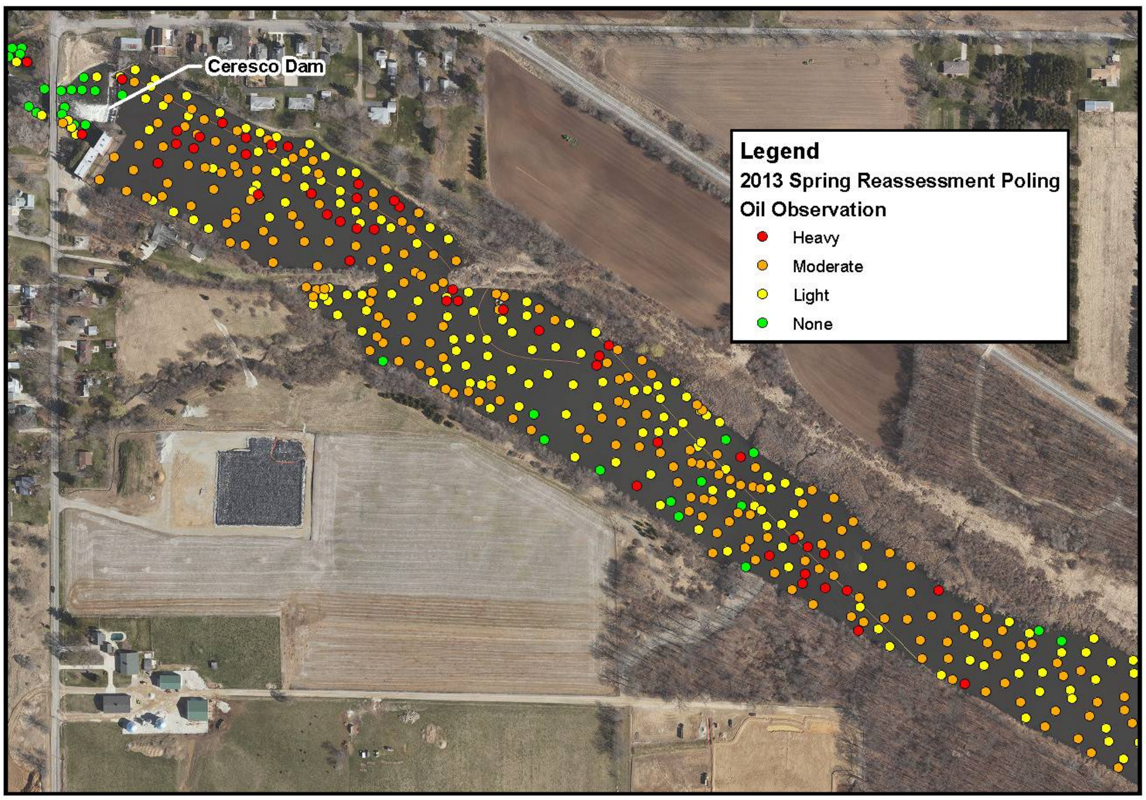
The accumulation and footprint of submerged oil in the north and south coves of Morrow Lake increased between the spring and late summer of 2012. This expansion confirmed the migration of submerged oil from the upstream delta during a period of low river flow. The heavy and/or moderate submerged oil footprint in the Morrow Lake Delta through the late summer of 2012 was approximately 55.5 acres.

5.2.13. Spring 2013 Submerged Oil Reassessment

In accordance with the 2013 Submerged Oil Removal and Assessment Work Plan (SORA) (Enbridge, 2013a), Enbridge performed the Spring 2013 Submerged Oil Reassessment between the confluence of Talmadge Creek with the Kalamazoo River and the Morrow Lake Dam to identify submerged oil areas remaining in the system. This reassessment was conducted in May and June 2013 at locations where submerged oil was identified in previous reassessments during 2010, 2011, and 2012.

Of 7,795 poling locations assessed, there were 2,863 'light' locations, 1,033 'moderate' locations, and 421 'heavy' locations. The results of the Spring 2013 Submerged Oil Reassessment at the Ceresco impoundment are depicted in Figure 32 below.

Figure 32 - Spring 2013 Submerged Oil Reassesment Results at Ceresco Impoundment



5.2.14. 2013 Submerged Oil Recovery – Dredging

Pursuant to the March 14, 2013 Order, the FOSC required Enbridge to dredge key locations in the Kalamazoo River containing the largest areas of recoverable heavy and/or moderate submerged oil, as identified by the Spring 2012 Submerged Oil Reassessment, 2012 LSR, and 2012 Sediment Trap Monitoring. These areas consisted of the Ceresco Dam Impoundment, the Mill Ponds Impoundment, the Morrow Lake Delta/Fan, and sediment traps that exceeded the submerged oil trigger as outlined in the approved Sediment Trap Monitoring and Maintenance

Plan (Enbridge, 2012b). The Sediment Trap program, including monitoring and dredging, is discussed further in Section 5.7. EPA and Enbridge finalized the specific areas to be dredged using data from the Spring 2013 Submerged Oil Reassessment.

5.2.14.1. Legacy Contamination Evaluation

Prior to dredging, Enbridge conducted a legacy contamination evaluation to determine if pre-existing sediment contaminants would be exposed during dredging activities. Enbridge reviewed available historical sediment sampling data; however, the results were inconclusive in identifying what would be encountered during dredging operations. Therefore, Enbridge performed an extensive evaluation of the legacy contaminants and developed the Legacy Contamination Data Gap Evaluation Work Plan (Enbridge, 2013b).

The legacy data gap evaluation included collection of sediment cores in the proposed dredge areas. The sediment cores were advanced to five ft below the sediment surface, unless refusal was met, which provided a sufficient general sediment profile that extended into pre-industrialized native sediment strata. The cores were logged and sampled at one-foot intervals.

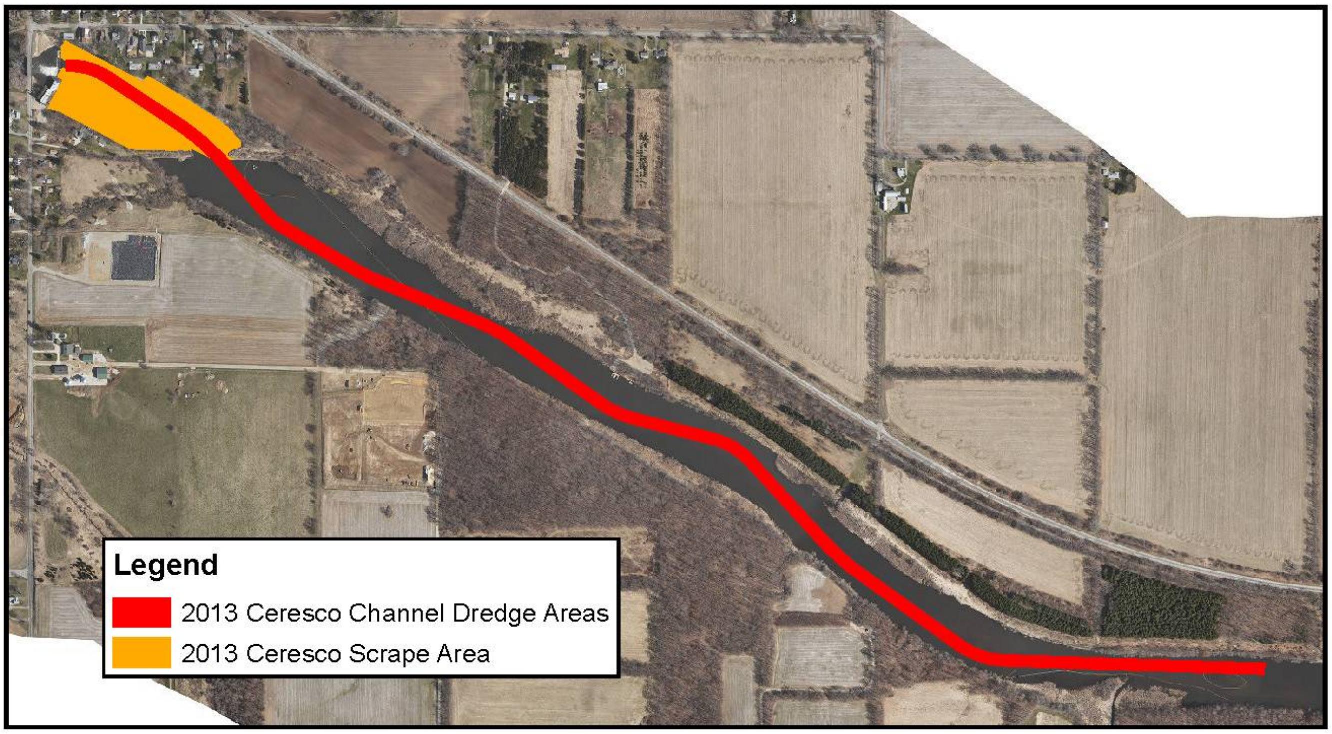
In total, 217 cores were collected from the Ceresco, Mill Ponds, and Morrow Lake Delta impoundments, as well as the MP 10.40 North, MP 10.50 L2, and MP 21.50 sediment traps. From those cores, 751 sediment samples were submitted for laboratory analysis. Also, 261 sheen net samples were collected from the 217 cores and submitted for laboratory analysis. The analytical results of the sediment and fingerprint samples were delivered to EPA. Enbridge did not request any changes to the dredge footprint based on the results of the legacy data gap evaluation.

5.2.14.2. Ceresco Impoundment

The Ceresco Dam Impoundment was an anthropogenic depositional area located immediately upstream of Ceresco Dam from MP 4.25 to MP 5.80, which included the Ceresco sediment trap. Results of 2012 and 2013 reassessment and sediment trap poling indicated that the heavy and/or moderate submerged oil footprint was 28.0 acres at the Ceresco Dam Impoundment.

As an alternative to dredging the entire extent of heavy and/or moderate submerged oil, Enbridge developed the Ceresco Alternative Oil Removal Work Plan (Enbridge, 2013c). Pursuant to the approved plan, Enbridge dredged a pilot channel (Figure 33), installed containment to protect the banks, notched Ceresco Dam, and allowed the impounded water to lower into the pilot channel. The drawdown exposed previously submerged oil and/or oil-containing sediment above the water surface, effectively removing it from the new river channel and eliminating the direct source of oil sheen to the river. The newly formed overbank margins from MP 5.60 to Ceresco Dam were excavated pursuant to EPA's Order. EPA transitioned final management of the margins from MP 4.25 to MP 5.60 to MDEQ primary oversight pursuant to MDEQ's Order, which was issued to Enbridge on November 1, 2010. MDEQ's Order addressed the complete investigation of residual effects of the discharge, along with long-term remediation and restoration of affected areas to meet state law requirements. This phased approach eliminated sheening to the river to the same extent as dredging, while simultaneously restoring the river to natural pre-dam flow conditions.

Figure 33 – Dredge Areas (2013) at Ceresco Impoundment



Prior to dredging the pilot channel, Enbridge constructed a 20-acre dredge pad adjacent to the south bank of the river. The dredge pad contained a mixing and staging area and two dewatering pads. The pads were constructed with impervious polyethylene liner and overlaid with sand and stone. The drainage layer sloped to a sump. Each dewatering pad was surrounded by a lined berm to ensure dredge material stayed within the pad.

Enbridge hydraulically dredged the Ceresco pilot channel from August through October 2013. The channel was dredged to a width of seventy ft from MP 4.25 to MP 4.80. All of the soft sediment was removed from the pilot channel, resulting in dredge depths ranging from less than one foot to greater than seven ft. Approximately 126,000 cubic yards of sediment were removed during pilot channel dredging operations.

Figure 34 – Sediment Dewatering and Processing Pad at Ceresco Impoundment (10/18/2013)

Dredged sediment was transferred through discharge pipes as slurry to the dredge pad (Figure 34) where it was dewatered in geotextile tubes. Water flowed downhill through the stone and sand of the pad and into the sumps. Water was treated to remove particulates and soluble phase organics, sampled, and discharged to the river, in accordance with the National Pollutant Discharge Elimination System (NPDES) permit. Sediment was dewatered in geotextile tubes for at least 10 days, solidified with cement, and shipped to an approved off-site disposal facility.

After the pilot channel was dredged, containment was installed along the banks. A siltation curtain was installed on top of the banks, suspended between anchor posts, and ballasted to the river bed. This curtain prevented downstream migration of sediment from the pilot channel margins during the drawdown. The curtain was also suspended from hard containment boom and ballasted to the river bottom at the edge of the pilot channel to prevent sediment from sloughing from the edges of the pilot channel and migrating downstream. Containment remained in place until final bank restoration work was completed. The pilot channel sidewalls remained relatively vertical, without major sloughing, after dredging was complete.

Following installation of the pilot channel containment, Enbridge notched the Ceresco Dam spillway to gradually lower the water level in the impoundment. Notching was conducted daily from October 30 through November 5, 2013 (Figures 35 and 36), lowering the water level by approximately four ft. Enbridge removed an additional 1.7 ft from the dam from November 17 through 19, 2013 to further dewater some of the overbank areas that were still saturated. Enbridge conducted dam notching and final dam structure removal activities pursuant to the MDEQ Order.

Figure 35 – Ceresco Impoundment Dredge Area Prior to Notching Ceresco Dam (10/18/2013)

Figure 36 – Ceresco Impoundment Dredge Area After Notching Ceresco Dam (11/7/2013)

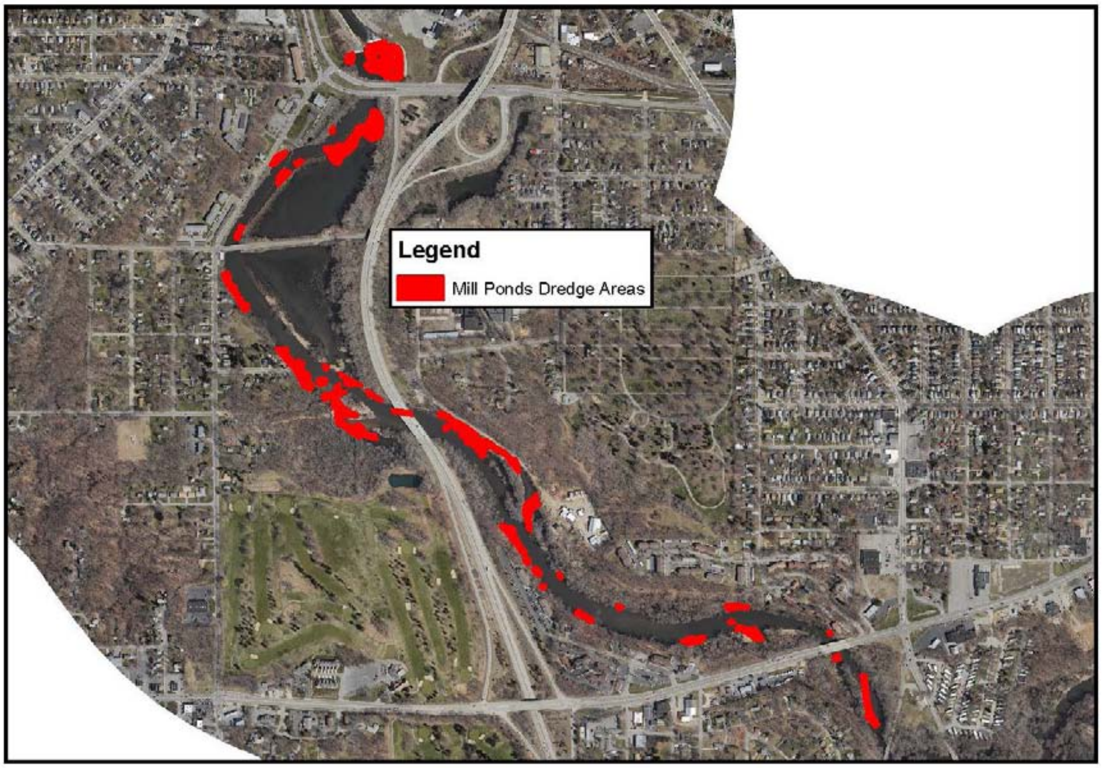
The most heavily oiled location in the Ceresco Impoundment was located between the former railroad trestles at MP 5.60 and Ceresco Dam, known as the bowl. Enbridge excavated the top one foot of newly exposed overbank margins in this area to prevent runoff migration to the river. Excavation began on November 12, 2013. Approximately 30,000 cubic yards of affected soil were removed from the bowl, transported to the Ceresco dredge pad, solidified, and transported to an approved off-site disposal facility.

Newly exposed overbank soil from MP 5.8 upstream to MP 4.25 was temporarily stabilized in the fall of 2013 with anchored geotextile fabric and limited seeding. The remaining affected overbank soil was transferred to MDEQ primary oversight for investigation, characterization, and management activities, pursuant to the MDEQ Order.

5.2.14.3. Mill Ponds Impoundment

In accordance with the approved 2013 SORA (Enbridge, 2013a), dredging operations were conducted at the Mill Ponds Impoundment area from MP 13.90 to 15.70, including the MP 14.75 RDB sediment trap (Figure 37). There were 38 polygons identified as target dredge areas from moderate and heavy poling delineations resulting from the Spring 2013 Reassessment.

Figure 37 – 2013 Target Dredge Areas in the Mill Ponds Impoundment



Sediment removal was conducted by hydraulic dredging from late August through December 2013. A Toyo pump connected to a pontoon excavator and conveyance line was also used to remove sediment from two dredge polygons close to the dam at MP 15.70. Operations were suspended due to weather conditions in December 2013.

Figure 38 – Dredge Unit Operating at the Mill Ponds Impoundment (9/25/2014)

Sediment removal depths were confirmed according to The Sediment Dredge Depth and Area Determination Addendum to the 2013 SORA (Enbridge, 2013a). Soft sediment was removed to an average two-push sediment depth calculated for each dredge polygon based on reassessment poling data to a maximum dredge depth of two ft. Dredging (Figure 38) was complete when the average two-push sediment depth was achieved, or when a gravel layer was encountered. Pre-dredge and post-dredge survey data were generally collected using Total Station survey equipment at pre-established points along a survey grid to maintain consistency between survey events. Post-dredge surveys were conducted immediately following dredging to reduce potentially erroneous sediment measurements caused by sediment movement and infiltration.

Hydraulically dredged sediment was pumped as slurry through a conveyance line to an adjacent dewatering and processing pad. Slurry was dewatered in geotextile bags. Sediment from the Toyo pump operations was collected in weir tanks, pumped in tanker trucks, transported to the dredge pad, and dewatered in geotextile bags. Dewatered sediment was solidified and transported to an approved off-site disposal facility. Water from dredging operations was collected in a sump, treated to remove particulates and soluble phase organics, sampled, and discharged to the river, in accordance with the NPDES permit requirements. Dredging was completed at 32 polygons during 2013 prior to river icing conditions preventing the continuation of work in December. Completion of the remaining six polygons would be conducted during the spring/summer of 2014. As a result of 2013 dredging operations at the Mill Ponds Impoundment, Enbridge removed approximately 22,000 cubic yards of sediment and treated approximately 43,000,000 gallons of water.

5.2.14.4. Morrow Lake Impoundment

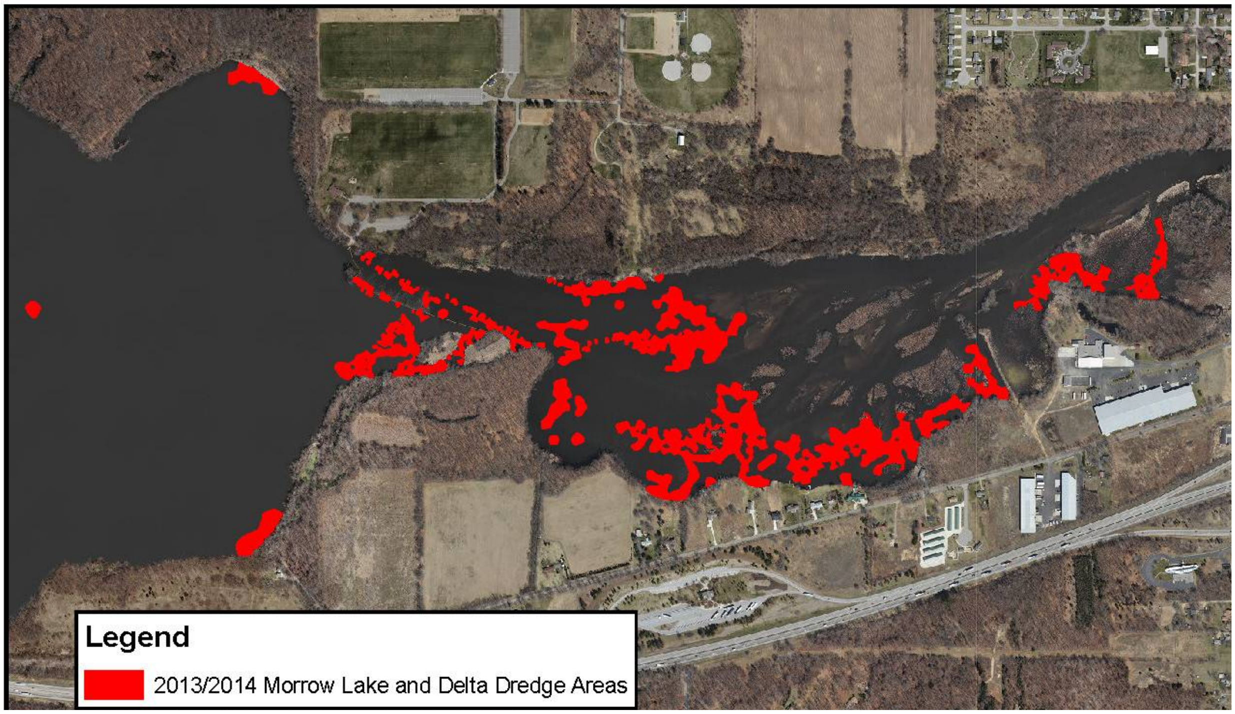
In accordance with the approved 2013 SORA (Enbridge, 2013a), dredging operations were planned for moderate and heavy submerged oil polygons in the Morrow Lake Delta and Morrow Lake from MP 36.50 to 39.85, including the MP 36.75 (Delta A), 37.75 islands, and Delta Z sediment traps. There were 47 polygons identified as target dredge areas (Figure 39) from moderate and heavy poling delineations resulting from the Spring 2013 Reassessment.

Enbridge selected the CCP Development, LLC (CCP) property for construction of the Morrow Lake Delta and Morrow Lake dredge pad. Site preparation activities were initiated on June 17, 2013. However, on June 27, 2013 Comstock Township notified Enbridge that they were not in compliance with the township's permit and zoning regulations. The township required Enbridge to submit a Site Plan Review application to the Planning Commission and receive approval prior to continuing work activities. Enbridge stopped dredge pad construction and applied for the proper permits and zoning change. On August 22, 2013 the Comstock Township Planning Commission denied Enbridge's Site Plan application for the CCP dredge pad location based on potential negative impacts to adjacent businesses and residential properties. Enbridge demobilized equipment and materials from the E3.5 staging area and from the CCP dredge pad from July 8 through 12, 2013.

Due to the denial of its Site Plan application by Comstock Township, Enbridge determined that it would not be able to complete the required dredging at Morrow Lake and Morrow Lake Delta by the December 31, 2013 deadline required by the 2013 EPA Order. On November 11, 2013 Enbridge submitted a formal request to EPA for an extension of the deadline to complete the required dredging activities. On November 21, 2013 EPA denied Enbridge's request and directed Enbridge to continue to perform the required work until all tasks outlined in the 2013 EPA Order were complete. EPA also directed Enbridge to pursue access and Site Plan approval at multiple dredge pad locations so that contingency options would be available.

As directed by the FOSC, Enbridge submitted Site Plan applications for three separate dredge pad locations to the Comstock Township Planning Commission on January 24, 2014. On February 17, 2014 the Comstock Township Planning Commission unanimously approved Enbridge's Site Plan application to use the Benteler Automotive property as a dredge pad for the continued sediment removal actions at Morrow Lake and the Morrow Lake Delta, as required by the March 14, 2013 Order.

Figure 39 – 2013 Target Dredge Areas at Morrow Lake and Morrow Lake Delta



5.2.15. 2014 Submerged Oil Recovery-Dredging

Since some dredging activities required by the March 14, 2013 Order were not completed by the December 31, 2013 deadline, the FOSC required Enbridge to continue dredge activities in 2014 until complete. Locations not completed in 2013 consisted of six polygons within the Mill Ponds Impoundment, all polygons in the Morrow Lake Delta/Morrow Lake impoundment, and the MP 36.1 sediment trap. The MP 36.1 sediment trap dredging conducted in 2014 is discussed further in Section 5.7.

5.2.15.1. Mill Ponds Impoundment

In accordance with the approved 2013 SORA (Enbridge, 2013a), dredging operations continued at the Mill Ponds Impoundment area at six of the 38 moderate and heavy target areas where dredging was not completed in 2013 due to icing conditions in the river. The remaining target areas were located along the main channel side of the North Mill Pond. Hydraulic dredging activities commenced on May 12, 2014, and all required dredging with the six target areas was completed by May 23, 2014. In total, approximately 1,100 cubic yards of sediment were removed from the Mill Ponds Impoundment in 2014.

As in 2013, hydraulically dredged sediment was pumped as slurry through a conveyance line to the dewatering and processing pad. Slurry was dewatered in geotextile bags. Dewatered sediment was solidified with saw dust and transported to an approved off-site disposal facility. All dredged waste was transported off-site by June 5, 2014. Water from dredging operations was collected in a sump, treated to remove particulates and soluble phase organics, sampled, and discharged to the river, in accordance with the NPDES permit requirements. Upon completion of sediment and water management activities, Enbridge decommissioned the dredge pad and conducted site restoration.

5.2.15.2. Morrow Lake Impoundment

In the spring of 2014, EPA required Enbridge to prepare and submit a Work Plan Addendum to the 2013 SORA describing all dredging activities, sequencing, and waste management tasks for the Morrow Lake Delta and Morrow Lake dredge polygons. Enbridge prepared the 2014 Morrow Lake Delta and Morrow Lake Submerged Oil Removal Addendum to the 2013 SORA which was approved by the EPA on June 4, 2014.

Construction of the 38-acre dredge pad at the Benteler Automotive property commenced in early April 2014 and was completed by the end of May 2014. The dredge pad design incorporated several features resulting from lessons learned from the 2013 dredged sediment management activities. These features included the use of Del tanks equipped with shaker systems designed to separate out course grained materials from the dredge slurry. Subsequently, the dredge slurry passed through large slurry tanks to promote additional sediment settling prior to being pumped into geotextile bags for additional dewatering. These features greatly improved the success in dewatering the dredge slurry throughout the Morrow Lake Impoundment dredging efforts.

Dredging efforts in the Morrow Lake Delta commenced on June 4, 2014. Dredging was accomplished utilizing three standard hydraulic dredge units and two Toyo pump dredge units. Dredged sediment was pumped as slurry through conveyance lines to the Benteler dewatering and processing pad. Water that decanted from the geotextile bags was collected in a 2,000,000 gallon sump, pumped through a series of large clarifying tanks and subsequently treated through a series of granular activated carbon (GAC) vessels, sampled, and discharged back to the river under the NPDES permit requirements.

Dredging of the 47 target polygons was completed on September 10, 2014. Dredge areas and dredge depths were verified by similar survey methods employed in 2013. In total, 104,649 cubic yards of sediment were dredged from the Morrow Lake and Morrow Lake Delta impoundment in 2014. Dewatered sediment was solidified (as necessary), transported, and disposed of at approved disposal facilities. All dredged sediment was transported off site by October 23, 2014. Upon completion of sediment and water management activities, Enbridge decommissioned the dredge pad and conducted site restoration.

5.2.16. FOSC Commentary on the Effectiveness of Submerged Oil Recovery

New sources of heavy crude oils, like diluted bitumen, and increasing transportation of those oils requires changes in the way emergency personnel respond to oil spills in the Great Lakes and other freshwater ecosystems. Strategies to recover heavy oils must consider that the oils may suspend or sink in the water column, mix with fine-grained sediment, and accumulate in depositional areas. Early understanding of the potential fate and behavior of diluted bitumen product, when combined with timely, strong conventional recovery methods, can significantly influence response success.

The Enbridge Line 6B pipeline release of diluted bitumen into the Kalamazoo River downstream of Marshall is one of the largest freshwater oil spills in North American history. The unprecedented scale of impact and massive quantity of oil released required the development and implementation of new approaches for detection and recovery. As mentioned in a preceding section, during the onset of the response, conventional recovery techniques were employed for the initially floating oil and were highly successful. However, volatilization of the lighter diluent, along with mixing of the oil with sediment during flooded, turbulent river conditions (collectively weathering), caused the oil to sink and collect in natural deposition areas in the river. For more than four years after the spill, recovery of submerged oil remained the predominant operational focus of the response.

The recovery complexities for submerged oil mixed with sediment in depositional areas and long-term oil sheening along approximately 38 mi of the Kalamazoo River led to the development of a “multiple lines of evidence” approach comprised of six major components: geomorphic mapping, field assessments of submerged oil (poling), systematic tracking and mapping of oil sheen, hydrodynamic and sediment transport modeling, forensic oil chemistry, and net environmental benefit analysis (NEBA). The FOSC considered this information in determining the appropriate course of action for each impacted segment of the river.

Agitation toolbox techniques: The agitation tactics and strategies developed and implemented in 2010 and 2011 were successful at causing submerged oil to rise to the surface and sheen; however, a large portion of the oil and oiled sediment remained suspended in the water column and likely was transported and settled in downstream depositional areas of the river. Field studies to determine the effectiveness of agitation were conducted during 2012 in containment cells in representative depositional areas of the river previously determined by poling assessments to have moderate and heavy oiling. The study results, although limited in spatial extent and conducted after the oil and sediment were mixed by agitation techniques, indicate that most of the oil remained mixed with sediment and resettled to the bottom after agitation. More studies are necessary to determine the effectiveness and the effects of agitation in different physical settings. Pending the outcome of these additional studies, use of agitation strategies for submerged oil recovery should be considered only for discrete target areas where complete containment is possible and where careful NEBAs justify the approach. Examples of such areas are off river or out of direct river currents locations that can be completely contained with full silt curtains, including: backwaters, side channels, oxbows, impounded areas where containment can be strictly controlled to minimize downstream migration, and areas behind constructed weir dams where containment can control both surface and subsurface transport of oil and suspended sediment. One possible exception for FOSC consideration might be to use agitation as a tactic to liberate these sediments so that they may flow to natural and more easily accessed depositional points for ultimate collection. Finally, to the extent that highly controlled agitation described above is used, the timing of the implementation of such action is a critical consideration since the more weathered the bitumen becomes, the less likely it is to remain suspended and recoverable. There is a limited window of time that agitation should be considered as an effective tool.

Dredging: Ultimately, the dredging of sediments contaminated with submerged oils from sediment traps located within key natural depositional areas of the river proved to be the most reliable and effective way to recover residual submerged oils. Using the multiple lines of evidence approach for locating and characterizing the oil and the NEBA as a filter to evaluate recovery approaches, it was consistently obvious to the FOSC that hydraulic and sometimes mechanical dredging were superior methods.

Natural Attenuation: In a few key areas, as supported by NEBA results and/or requested by MDEQ, the FOSC decided to allow the submerged oil to remain in place. This decision, however, must consider the longer term implications of this do nothing approach. There remains the potential for extreme weather and significant rainfalls to change river velocity and remobilize at least a portion of this oil. This could lead to recontamination of areas previously cleaned. Long-term monitoring of environmental and benthic organism impacts should also be considered when following this course of action. Public outreach and messaging for future oil sightings in these areas must occur. Additionally, long-term monitoring programs and a clear understanding of the agency responsible for each area are important considerations. In the case of this site, all such areas are being monitored and managed by MDEQ under its authority and Order with Enbridge.

5.3. Overbank Reassessment and Recovery

5.3.1. Shoreline Cleanup Assessment Technique (SCAT)

The discharge occurred during a flood event, causing water levels to be elevated in Talmadge Creek and the Kalamazoo River. As a result, oil discharged into the floodplain, backwaters, and extensive overbank areas of forested floodplains, islands, and wetlands. As floodwaters receded, oil of various thicknesses covered these shoreline and overbank areas. The SCAT procedure was used to identify, characterize, and document affected shoreline and overbank areas and to recommend methods for oil removal. The SCAT process generally followed the procedures developed by NOAA, which were originally intended for rapid assessment of shoreline habitats in a marine setting. The SCAT procedures were successfully adapted to a freshwater, riverine environment by modifying cleanup methodologies to address overbank habitat types. The SCAT process was conducted systematically along the shorelines, defined as the area from the water's edge to 10 ft from the water's edge, and the overbank, defined as areas further than 10 ft from the water's edge, using the following five-step iterative process:

1. initial SCAT inspection,
2. operational removal of oil and/or oiled materials using a list of potential SCAT response techniques,
3. post removal inspection by EPA and Enbridge,
4. final SCAT assessment, and
5. EPA approval.

Implementation of the SCAT process began informally through EPA-initiated conversations with the Natural Resource Damage Assessment (NRDA) trustees and was coordinated by the Environmental Unit in the Planning Section. The shoreline, along both the left and right descending banks of Talmadge Creek and the Kalamazoo River, was divided into 0.25-mi segments. An initial SCAT inspection of each segment was conducted from August 2 to 10, 2010 as a joint effort with the NRDA trustees. Teams consisting of EPA, NOAA, USFWS, Michigan

Department of Natural Resources and Environment (MDNRE), and Enbridge personnel identified and estimated the areas of specific oiling and substrate conditions within each segment. SCAT teams characterized oiling conditions using standard SCAT terminology and recorded percent coverage of a specific oiling condition within a SCAT zone on a SCAT field map and form. GPS coordinates were also recorded for each oiled zone identified as needing cleanup action. During this assessment, it became clear that assessing only the shoreline was inadequate, despite being the classic mission of SCAT. Oil was stranded inland and not always visible from the water's edge. SCAT teams provided recommendations for revisiting areas for potential overbank oiling.

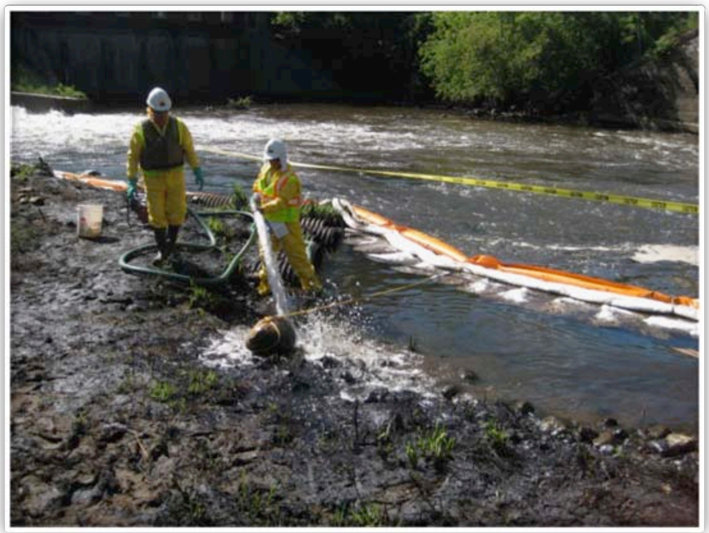


Figure 40 – Personnel Flushing Impacted Shoreline at MP 6.00 (8/15/2010)

On August 10, 2010 Enbridge, EPA, USFWS, and MDNRE completed development of Phase 1 shoreline cleanup methods. These methods included gross oil removal by cutting oiled vegetation, removing oiled debris and soil, and low-pressure ambient water flushing (Figure 40). SCAT teams provided recommendation for implementation of specific shoreline cleanup methods within each 0.25-mi segment.

Operations personnel conducted Phase 1 removal of oil and/or oiled materials in accordance with the SCAT recommendations. Phase 1 of the shoreline cleanup effort resulted in removal of much of the visibly oiled vegetation, oiled debris, and oiled large woody debris in the water, on the banks, and overhanging the river within 10 ft of the shoreline. Additionally, oiled rock and gravel banks were flushed and manmade structures were pressure washed. Following completion of Phase 1 shoreline cleanup efforts, visible oil was removed from portions of the shoreline. However, oil-saturated soil continued to generate a persistent sheen in other portions of the shoreline, and certain overbank areas had not been assessed.

To address the remaining oiling impacts in both the shoreline and overbank areas, EPA, MDNRE, and Enbridge began development of Phase 2 cleanup methods. On August 13, 2010 testing was conducted to determine the potential effectiveness of three methods: cold water flushing, in-situ thermal destruction, and soil removal by scraping. Flushing and scraping were moderately effective; however, both techniques resulted in erosion. In-situ thermal destruction was ineffective. This testing, along with the work of the Environmental Advisory Group discussed in Section 7.5.2, was used to prepare the Phase 2 cleanup methods, which included:

- Portable vacuum removal and absorption: Pooled oil was removed using portable vacuum or absorption techniques (e.g., snare/pom-poms, sorbent pads).

- Manual and mechanical means: Manual techniques (e.g., shoveling, scraping, raking or digging) were used to remove oil, oil-impacted soils, and oily debris. In areas where soils were saturated with oil and manual removal was impractical or unsafe, mechanical removal was performed using heavy equipment.
- Vegetation removal and bagging: Oiled herbaceous and shrub vegetation was removed by cutting. All cut oiled vegetation was bagged immediately and segregated from other types of oily wastes (e.g., sorbents, soil, etc.). Only the above-ground portion of vegetation was removed; efforts were made to limit disturbance of the root systems of plants to maintain bank stabilization and erosion control functions. Tree trunks with oiled bark were not cut; however, the oil was removed with sorbents and/or flushing.
- Low pressure/high volume ambient water washes: Ambient water from Talmadge Creek or the Kalamazoo River was pumped to mobilize oil trapped in stream bank or overhanging vegetation for collection using sorbents and/or skimmers. Hard boom or underflow dams were used to facilitate collection and recovery of remobilized oil and to prevent additional oiling of downstream reaches. Flushing was not conducted in areas where the water movement caused erosion of unconsolidated bank sediments.
- High pressure ambient water washes: Oiled manmade structures and larger rocks were washed using high pressure ambient water from Talmadge Creek or the Kalamazoo River.

In order to adapt the SCAT process to a riverine system, SCAT personnel identified the various habitat types within the shoreline and overbank areas of the system, which included:

- shoreline;
- floodplain, oxbows and ponds, and mud areas;
- emergent wetlands;
- oiled debris, oiled manmade structures, and larger rocks;
- large woody debris;
- aquatic vegetation holding floating oil;
- oiled mixed sand and gravel;
- turf; and
- islands.

SCAT personnel applied the Phase 2 cleanup methods to the habitat types to create habitat-specific Phase 2 cleanup recommendations.

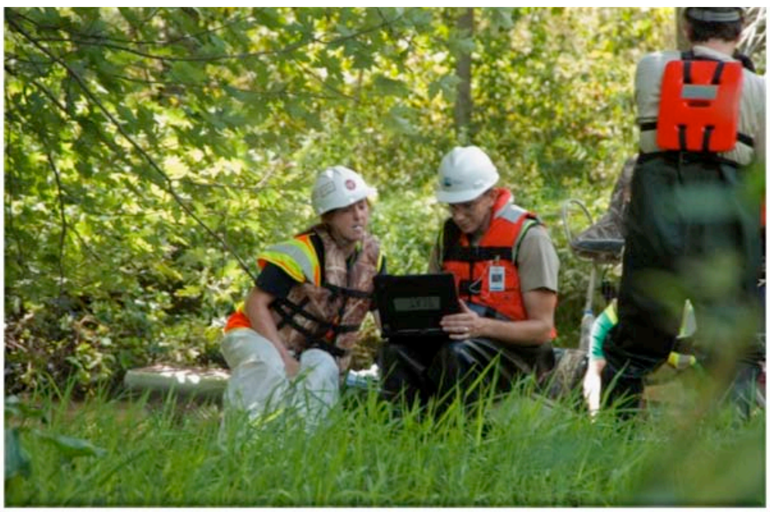
While Phase 2 cleanup methods were under development, a second SCAT assessment was conducted from August 15 through 21, 2010. SCAT teams assessed the shorelines to characterize oiling after implementation of Phase 1 cleanup methods, identified, and characterized oiling in the near shore overbank and assessed islands in Division C. This SCAT assessment was conducted by a three member team consisting of federal, state, and Enbridge representation. The federal representative was usually EPA; however, USCG occasionally filled the position. Teams recorded oiling observations and information related to habitat type, in accordance with the Manual of Vegetation Identification. SCAT personnel prepared cleanup recommendations for each 0.25-mi segment based on habitat type, feature, and the cleanup objectives.

The third SCAT assessment was conducted from August 20 through September 4, 2010. Teams assessed both the shorelines and overbank areas to a distance away from the river at which no evidence of primary or secondary hydraulic indicators or floodplain characteristics were observed. This SCAT assessment was also conducted by a three member team consisting of federal, state, and Enbridge representation. Teams recorded oiling observations and information related to habitat type, in accordance with the Manual of Vegetation Identification. SCAT personnel prepared cleanup recommendations for each 0.25 mi segment based on habitat type, feature, and the cleanup objectives.

Under EPA oversight, Enbridge conducted Phase 2 cleanup of each 0.25 mi section of the overbank, according to the SCAT recommendations. SCAT teams recommended operational maintenance of absorbent boom for many of the sites that continued sheening after SCAT cleanup due to the invasive nature of the cleanup techniques.

Once Enbridge believed that cleanup was completed in a specific 0.25 mi section, EPA and Enbridge conducted a post-removal inspection to verify that the cleanup methods were performed in accordance with the SCAT recommendations.

Figure 41 – SCAT Team Assessing the Kalamazoo River Overbank Area (9/14/2010)



Following the post-removal inspection, Enbridge requested a SCAT reassessment (Figure 41). EPA, MDEQ, and Enbridge inspected each section to verify that the recommendded cleanup techniques had been employed. If the SCAT team offered further recommendations for cleanup, Enbridge resumed cleanup efforts in that area. If the SCAT team had no further cleanup recommendations, the team signed a Shoreline Inspection form. In some cases obvious oil contamination remained; however, sign-off sheets only indicated that the recommended techniques had been employed. This allowed the SCAT process to be completed in a timely manner. Remaining overbank contamination was handled through a comprehensive reassessment and recovery process, discussed in the following subsections.

Enbridge prepared reports for each 0.25 mi section of the overbank, detailing the assessment, cleanup, and reassessment. The EPA Operations Section Division Director signed the reports after confirming their accuracy.

Prior to the response, there was not an electronic database for SCAT. During the initial SCAT assessment, teams documented assessment observations on hard copy field forms and manually inputted the data into a program run and hosted by EPA contractors. Although functional, it was not easily accessible to the team in a timely manner. Enbridge created a GIS database to document the assessment and cleanup status. Initially, hard copy forms were completed in the field and manually entered into the GIS database overnight. This process was labor intensive and time consuming. On August 25, 2010 the teams were issued digital tablets which were integrated into the GIS database.

Figure 42 – Response to Observations of Sheen Eminating from the Kalamazoo River Bank (4/28/2011)

5.3.2. Operations and Maintenance (O&M) of Sheening Sites

Following the initial SCAT cleanup process, the Operations and Maintenance (O&M) program was established to address overbank areas that exhibited ongoing sheening to the river. EPA and Enbridge developed a comprehensive list of overbank sites that required further monitoring and/or recovery. This list was initially comprised of sites that were not fully addressed through SCAT, additional sites that were identified by field teams, sites that were identified following investigation of land owner complaints, and sites that required additional monitoring or recovery following the initial submerged oil recovery activities, discussed previously in Section 5.2.4.

EPA and Enbridge conducted regular inspections of the sites, recorded observations on the daily O&M tracking spreadsheet, and prepared recommendations for response activities. Recovery operations requested by O&M teams including flushing, bagging, utilizing absorbent materials (Figure 42), vacuum recovery techniques, and skimming operations. Sites were cleared or transferred to MDEQ primary oversight based on a series of field observations.

5.3.3. Fall 2010 Recovery

In the fall of 2010, preliminary results of the O&M process were used to identify locations requiring immediate overbank recovery activities. Enbridge excavated the overbank portion of these sites but did not excavate the shoreline pursuant to the request of MDNRE. Figure 43 depicts the overbank sites addressed during the fall of 2010.

Figure 43 – Fall 2010 Overbank Recovery Areas

5.3.4. Winter 2010/2011 Reassessment and Recovery

Figure 44 – Excavation of MP 2.75 Island during Winter 2010 Overbank Recovery Activities

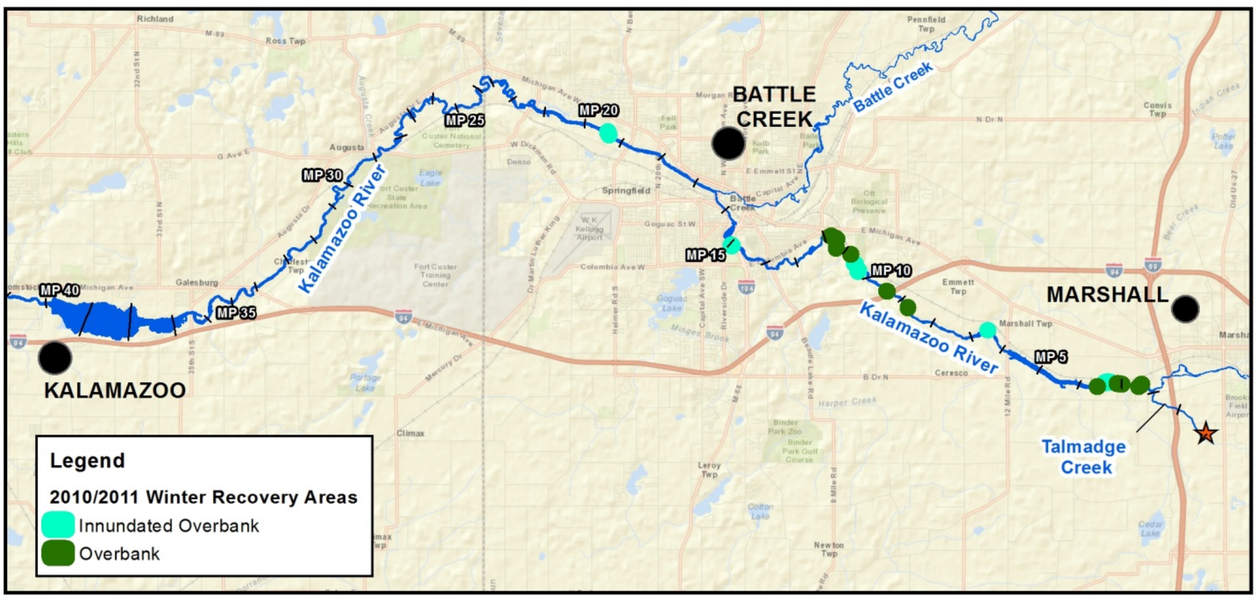
During the winter of 2010/2011, EPA and Enbridge reassessed high-priority locations that required recovery activities beyond those provided under the SCAT process and locations identified through the O&M process. Reassessment teams systematically characterized and delineated the oil-impacted soil, estimated the volume of soil requiring excavation, and conducted wetlands assessments, tree inventories, and cultural inventories. Based on the reassessment results, Operations Section Chiefs identified opportunities to continue clean up through winter excavation techniques (Figure 44) which minimized impact to sensitive environments.

The cold weather and associated subsurface frost allowed crews to access remote and ecologically sensitive wetland and overbank areas, causing less adverse effects on the ecology than would occur if access were made during thawed or warmer conditions. Innovative and ecologically-friendly methods, such as driving frost, were used to construct temporary access roads to remote areas.

Once site access was made via ice roads, Enbridge conducted excavation activities using low ground pressure equipment with wide pads, tracked dump trucks, dozers, small excavators, pumps, and isolation materials, including portable aqua dams. Cold temperatures solidified the oily sediment making it easier to remove, and excavated material was transported off site via ice roads. Figure 45 depicts the sites which were excavated from December 2010 through March of 2011.

Following excavation, EPA and Enbridge inspected the sites to ensure the removal requirements were met. Enbridge prepared close-out reports to summarize the work that was performed. EPA signed the reports after verifying the work was completed. Restoration was conducted using low ground pressure equipment and erosion control devices remained in place until vegetation was re-established.

Figure 45 – Winter 2010/2011 Overbank Recovery Areas



5.3.5. 2011 Shoreline and Overbank Reassessment Techniques (SORT)

Figure 46 –SORT Team Performing Surveys on the Kalamazoo River (5/12/2011)

The Spring 2011 Shoreline and Overbank Reassessment (2011 SORT) (Figure 46) was conducted to identify locations of oil along the shoreline and overbank area from Talmadge Creek to the Morrow Lake Dam and to assess the effectiveness of the previously conducted shoreline and overbank recovery activities. The reassessment addressed all areas inundated at the time of the spill as defined by the USGS Inundation Model for most of Calhoun County. The Federal Emergency Management Agency 100-year flood elevation was used for the portion of Calhoun County and Kalamazoo County which was not included in the USGS model. Previous SCAT data, high resolution aerial imagery, polarimetric imagery, light detection and ranging (LIDAR), and fluorescent LIDAR information were all used to define the reassessment area boundaries and detect remaining oil in the shoreline and overbank areas.

Results of the 2011 SORT indicated that Talmadge Creek generally contained areas of oil sheen along the creek and in overbank areas. Observations of vegetation staining and/or coating and other relatively smaller oil occurrences were also noted on the shoreline and overbank of Talmadge Creek.

Results of the 2011 SORT process indicated that the shoreline and overbank habitat and inundation level for the Kalamazoo River, from MP 2.00 to MP 40.00, varied based on the elevation leading away from the river. Consequently, oiling occurrences also varied and ranged from cover to trace in thickness. Most types of oiling occurrences, from tar balls to asphalt pavements, were observed. The most common observation was trace staining on debris and on trunks and stems. Sheen observations were generally in trace and sporadic distribution.

Some overbank areas could not be assessed through the SORT process due to the presence of ponded water. These areas were subsequently assessed using poling techniques during the Spring 2011 Submerged Oil Reassessment, as discussed in Section 5.2.5.

EPA and Enbridge used the results of the 2011 SORT process to target nine overbank sites requiring full excavation and 251 sites requiring smaller scale oil recovery work. These 251 sites included 237 tar patty sites.

5.3.6. 2011 Recovery

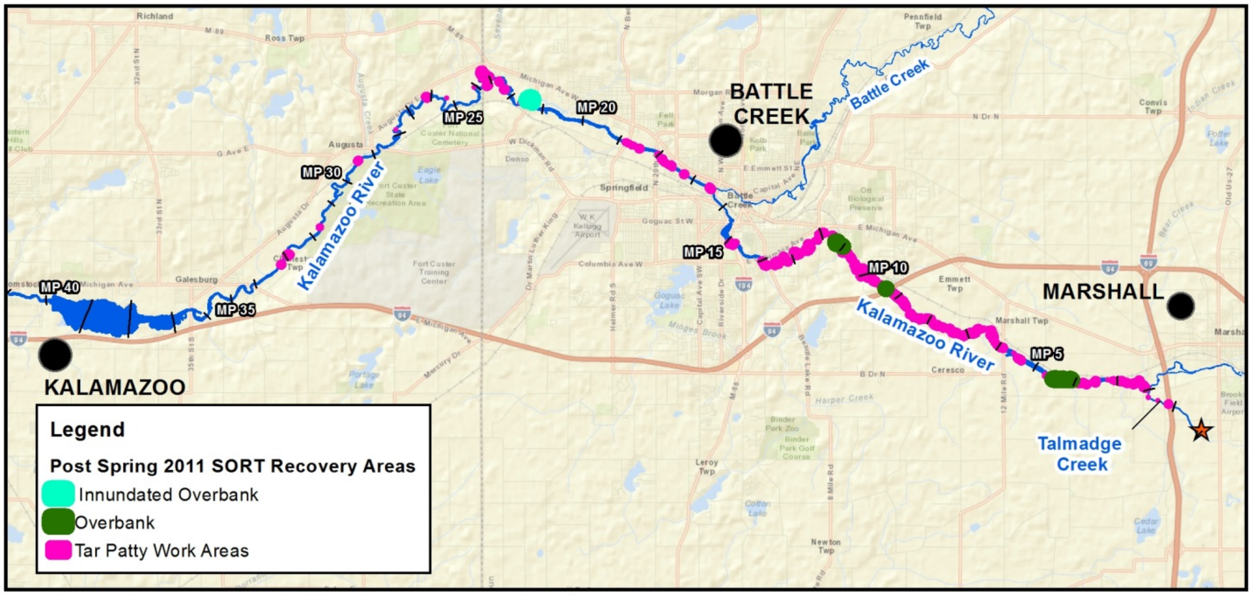
Figure 47 – Excavation of MP 4.50 LDB (8/9/2011)

Overbank recovery work was conducted throughout the summer and fall of 2011 at the locations identified during 2011 SORT. Excavations (Figure 47) were conducted in accordance with approved site-specific work plans at overbank and inundated overbank sites depicted in Figure 48.

In addition to excavation activities, smaller scale overbank oil recovery was conducted at 251 sites, including 237 tar patty sites (Figure 48). Under MDEQ oversight, Enbridge removed oil and impacted materials using low impact methods, including raking, shoveling, vegetation removal, low pressure cold water washing, and recovery with sorbent boom.

Even though removal activities were conducted at all 237 tar patty locations, 56 sites still showed evidence of remaining oil (e.g., surface staining, vegetation staining, etc.). These sites were identified as recurring tar patty sites. EPA visually inspected these 56 locations and confirmed that the cleanup objectives under the EPA Order were met (i.e. the sites were no longer sheening to navigable water). On August 8, 2011 EPA transitioned primary regulatory and compliance oversight responsibility for all 237 of the tar patty sites and Talmadge Creek to MDEQ. Enbridge's work on the tar patty sites and Talmadge Creek continued under the primary direction of MDEQ, pursuant to the MDEQ Order. EPA continued to monitor Enbridge's progress and support MDEQ's oversight, pursuant to EPA's July 27, 2010 Order and Supplement.

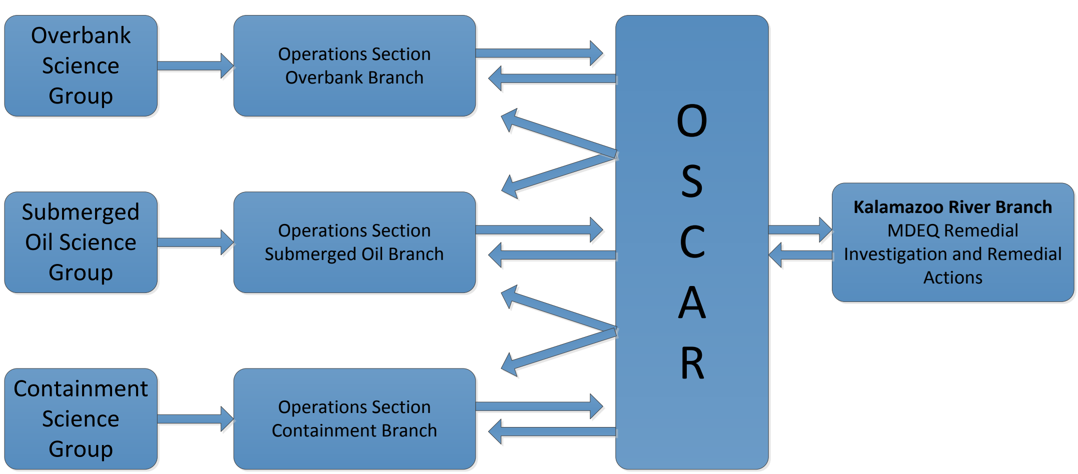
Figure 48 – Post Spring 2011 SORT Recovery Areas



5.3.7. Outstanding Sites Characterization and Reconciliation (OSCAR)

In September 2011 EPA, MDEQ, and Enbridge developed the Outstanding Sites Characterization and Reconciliation (OSCAR) process to identify overbank sites that required further action and transition the sites to the appropriate Group for final clearing. A total of 225 sites were systematically assessed through the OSCAR process to determine if removal activities should be handled through overbank excavations, overbank oil recovery activities, submerged oil recovery, or an alternate process to move toward closure.

Figure 49 – OSCAR Process



Following initial data review, Enbridge conducted expedited Remedial Investigations (RIs) at sites determined to require further action pursuant to EPA's Order. The expedited RIs were conducted in accordance with the MDEQ approved Remedial Investigation Work Plan for High Priority Outstanding Sites Characterization and Reconciliation (OSCAR) Sites Kalamazoo River (Enbridge, 2011a). A total of 18 sites from MP 6.75 to MP 26.23 were assessed through the expedited RI process. EPA reviewed the expedited RI data along with all other relevant data for these sites and, after determining that no further action pursuant to EPA's order was required, transitioned primary regulatory and compliance oversight responsibility of sites to MDEQ.

As a result of the OSCAR process, Enbridge conducted excavations in the fall of 2011, winter of 2011/2012, and spring of 2012 at the locations depicted in Figure 50, in accordance with approved site-specific work plans. Following excavation, EPA and Enbridge performed visual assessments to ensure that all oil-impacted sediments were removed. A secondary inspection was completed once all backfill and restoration was completed. Once the site was determined to be in compliance with the EPA Order, the site was transitioned to MDEQ primary oversight.

Figure 50 – Post OSCAR Recovery Areas

5.3.8. 2011/2012 Excavation of Talmadge Creek

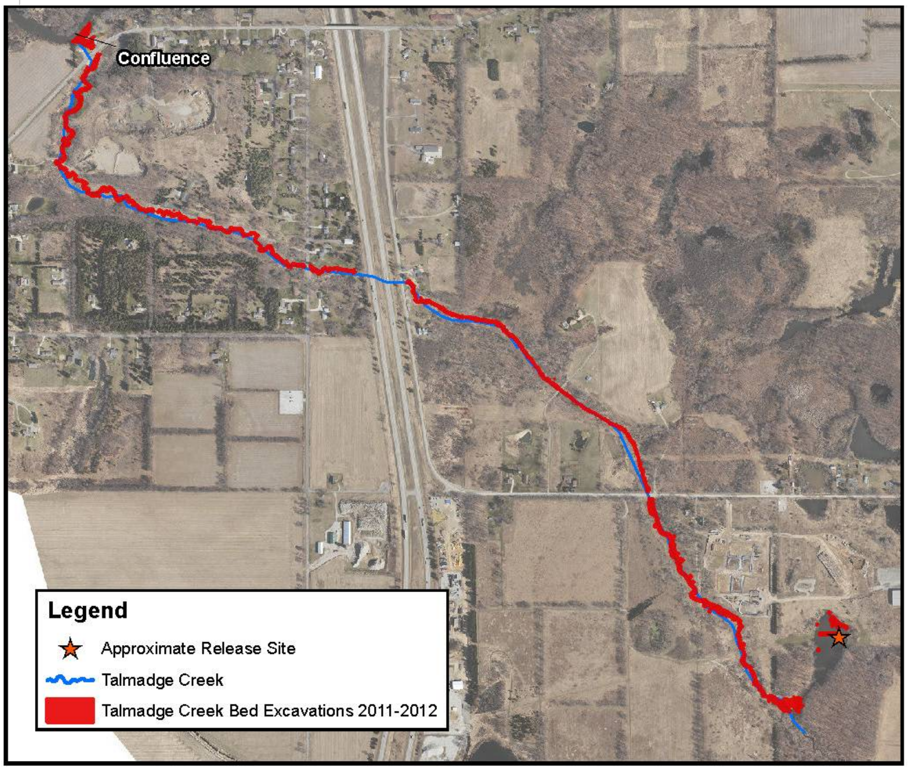
The 2010 excavation of Talmadge Creek, discussed in Section 5.1.1, only addressed the impacted banks. This excavation was ultimately ineffective in recovering all oil impacts, especially in the creek bed channel itself. Pursuant to MDEQ authority, Enbridge conducted an extensive RI of Talmadge Creek from September through November 2011. The vertical and horizontal extent of oil impacts were defined through poling, soil and sediment core collection and sampling, installation of temporary monitoring wells in the direct-push soil borings, and groundwater sampling via low-flow techniques.

In accordance with work plans approved by MDEQ (to optimize achievement of MDEQ long-term cleanup objectives), excavation of the creek began in November 2011 at the Source Area and continued working down gradient toward the confluence of the creek with the river. The horizontal and vertical extents of the excavation were defined by the RI, as well as visual assessments performed by Enbridge, MDEQ, and EPA during the excavation. Removal actions included recovery of any impacted material from the creek bed, banks, and overbank areas. Enbridge constructed sheet piling weirs and diverted the creek around the excavation areas. The diversion was accomplished by pumping the water approximately a quarter mile downstream to a hay bale dewatering structure which allowed the water to filter back into the creek with a minimal rise in turbidity. Excavation of Talmadge creek was completed in March 2012. Approximately 36,000 tons of sediment and overbank soil were removed from the two mi of affected creek (Figure 52).

Figure 51 – Excavation of Talmadge Creek at the Confluence with the Kalamazoo River (3/1/2012)

As the excavation progressed down gradient from the Source Area, restoration was conducted concurrently. Clean fill was used to replace the excavated material. Topsoil was used to fill in excavated overbank areas, while sand and gravel was used to replace the creek bottom. Coir logs were used to stabilize the banks of the creek and prevent erosion. Native grasses were planted on the overbank areas to prevent erosion.

Figure 52 – 2011/2012 Talmadge Creek Excavation Area



5.3.9. 2012 Shoreline and Overbank Reassessment (2012 SORT)

The Spring 2012 Shoreline and Overbank Reassessment (2012 SORT) was conducted to determine the presence of oil along the shoreline and overbank area from Talmadge Creek to the Morrow Lake Dam. The reassessment was conducted in March and April 2012, in accordance with the Consolidated Work Plan from Fall 2011 through Fall 2012 (Enbridge, 2011a).

Reassessment teams qualitatively determined the presence or absence of oil and/or oil sheen within targeted overbank areas along the affected river system from MP 2.25 of the Kalamazoo River to the Morrow Lake Dam. The reassessment activities were generally focused on the following areas:

- former excavation areas;
- impacted areas identified during the 2011 SORT reassessment that were inundated during the 2011 SORT reassessment activities; and
- impacted areas identified as having film, sheen, and/or pooled oil during the 2011 SORT reassessment.

Teams included EPA, MDEQ, and Enbridge representatives. The reassessment data was compared with previous overbank assessment results, which showed no additional recovery activities were necessary pursuant to EPA's Order.

5.3.10. FOSC Commentary on the Effectiveness of Overbank Assessment, Reassessment and Recovery

Early in the response, SCAT activities had limitations. They were modified to enable characterization of the vast areas of floodplain contamination and pooled water not amenable to more traditional assessments. Several programs were ultimately developed pursuant to EPA direction to achieve assessment, removal and decontamination, and reassessment in these areas. More specifically, the SORT, OSCAR, and O&M programs developed out of this need (as described in Sections 5.3.5, 5.3.7, and 5.3.2, respectively).

Some early cleanup attempts based on SCAT recommendations were limited in scope and not robust enough to affect the outcome desired by the FOSC. The FOSC revisited these SCAT work recommendations in many overbank areas and determined that a more aggressive approach would actually lead to a quicker long-term recovery than the more passive or gentle approaches recommended by the SCAT process. This was due in large part to the sheer volume and thickness of oil left behind in certain overbank areas after the floodwater receded. The ability of the FOSC to make these determinations early in the response allowed for less duplication of work for the project overall.

In summary, original overbank SCAT work, augmented with 2010 and 2011 O&M monitoring and ultimately by the OSCAR program, proved to be an extremely effective, systematic approach to resolving all oiled river bank, island, floodplain, and overbank areas of impact. The approach was greatly strengthened and enabled through the use of nimble GPS tools and robust GIS mapping routines for operations personnel to document, visualize, revisit, and track progress at all affected river sites that were being monitored and worked. By the end of 2012, all recovery of oil and impacted soils along the river and Talmadge Creek had been completed with a complete cessation of sheen or product release from those areas to the river. This allowed all project focus going forward to be on submerged oils assessment and recovery.

5.4. Containment Monitoring and Recovery

The response containment strategy consisted of deploying control point and protective containment booms, curtains, and other structures at strategic locations throughout the affected system, monitoring the containment, and conducting oil recovery using absorbent materials, vacuuming, or skimming.

Control points were deployed using containment boom, subsurface sediment curtain, and silt fencing to prevent the downstream migration of surface and subsurface oil and/or oil-containing sediment. The response team employed the following booming configurations based on the type of geomorphic setting, riverine structure, and access points:

- The shore-to-shore booming configuration (Figure 53) required a single span of boom deployed to cover the entire width of the river.

- The chevron booming configuration (Figure 54) required a single span of boom deployed to deflect oil around a sensitive area or to direct oil to recovery points on both banks.

- The cascade booming configuration (Figure 55) required deployment of multiple booms across the width of the river, allowing for vessel traffic up and down the river. Each additional segment was installed downstream in an overlapping position.

- The gate, or open chevron, booming configuration (Figure 56) required two segments of boom deployed across the width of the river to allow for vessel traffic up and down the river. The

Figure 53 – Shore-to-Shore Boom, Mill Ponds Impoundment (4/8/2011)

Figure 54 – Chevron Boom Upstream of Ceresco Dam (10/11/2011)

Figure 55 – Cascade Boom at Mill Ponds (9/1/2011)

Figure 56 – Gate Boom at Mill Ponds (10/8/2011)

upstream ends of both booms were secured in an overlapping position.

Control point booming locations were selected based on river characteristics (speed, depth, width, and bottom material), site access, and distance to upstream sources of impact and other control points. Subsurface containment locations were selected based on monitoring and reassessment activities in order to optimize containment of submerged oil in critical locations.

In addition to control points, protective surface and subsurface containment was installed throughout the system to minimize impact to sensitive areas. Enbridge deployed containment boom between a source of impact and the sensitive area. Enbridge also used protective containment boom to isolate previously affected areas until recovery methods were completed. Containment was typically deployed at the mouth of an inlet, around the entire area, or in a chevron configuration upstream of the area.

Containment boom was generally deployed according to the following priority sequence:

1. deployment of surface containment boom from downstream to upstream;
2. deployment of protective containment boom at areas of high ecological value;
3. deployment of protective containment boom from upstream to downstream;
4. deployment of submerged oil containment boom from downstream to upstream, not including submerged oil work sites; and
5. deployment of gabion baskets.

Enbridge regularly monitored all control point and protective containment boom locations for the accumulation of oil and oily debris. Oil recovery was conducted at containment points using the following methods:

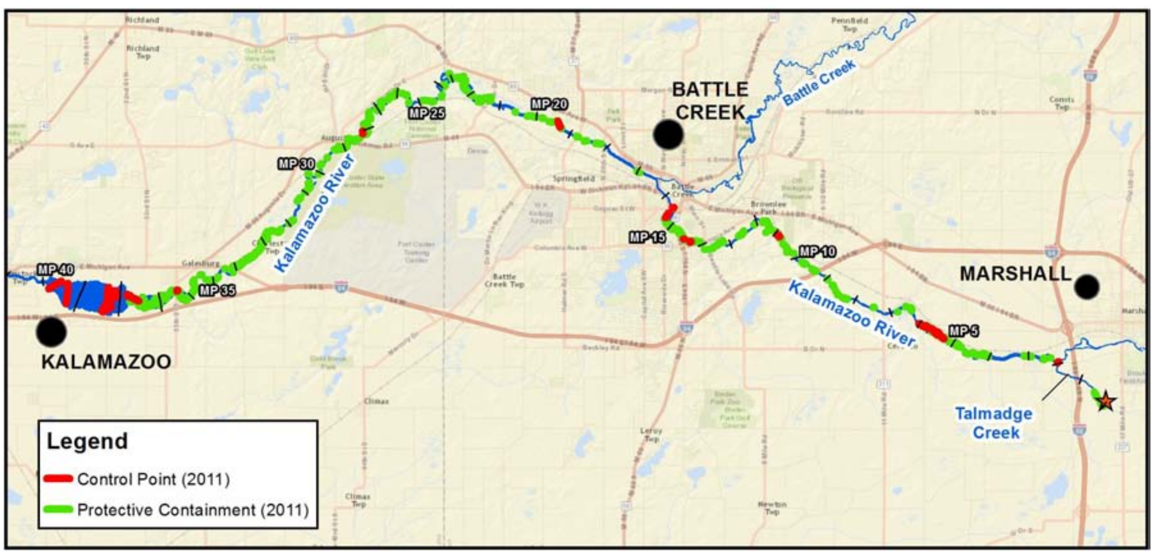
- Hand skimming: Personnel utilized hand tools such as dip nets, strainers, and pitchforks to lift the oil and debris out of recovery areas and placed it into containers for disposal.
- Gabion baskets: A sorbent snare was inserted into a frame that held it upright in the water column. As water traveled through the frame, submerged oil and other particulates in the water column adhered to the snare. The snare was removed, taken for disposal, and replaced with fresh material.
- Rotary skimming: Drum, mop, and brush skimmers with rotating oil-adhering surfaces were used at collection points for oil recovery. Recovered oil was mechanically removed from the surface and collected into a container for disposal.
- Vacuum trucks: Vacuum trucks collected free oil and/or affected sediment from containment areas. The recovered oil/water mixture was transported to Frac Tank City for separation prior to disposal at an approved off-site facility. Recovered sediment was transported to sediment dewatering pads.

5.4.1. 2011 Containment and Recovery

In accordance with the approved 2011 Containment Plan (Enbridge, 2011a), the 2011 containment strategy utilized control point and protective containment booming to minimize the impact of surface oil to downstream receptors, facilitate product recovery, and protect sensitive areas from additional impact.

During the late winter of 2010 and early spring of 2011, O&M teams observed river conditions, including freezing, ice movement, debris movement, presence of surface oil, and submerged oil migration. The FOSC used this information to determine the priority sequence and timing of containment deployment throughout the river system. In the spring of 2011, Enbridge redeployed nine control points and approximately 46 protective containment points (Figure 57) as weather conditions allowed. The teams performed routine inspections of the containment sites. Containment was added, adjusted, or removed based on the inspection results. During the summer of 2011, the number of containment sites increased to 14 control points and 59 protection containment locations. In fall 2011, the FOSC transitioned containment inspections from the O&M Group to the Containment Branch Monitoring Group. By winter 2011, the only remaining control point boom location was at the confluence of Talmadge Creek with the Kalamazoo River at MP 2.25. Additionally, 14 protective containment point locations remained deployed from MP 2.00 to the oxbow at MP 21.50.

Figure 57 – Control Point and Protective Containment Locations in 2011



5.4.2. 2012 Containment and Recovery

In accordance with the approved Consolidated Work Plan from Fall 2011 through Fall 2012 (Enbridge, 2011a), Enbridge implemented a containment strategy to prevent migration of oil from Talmadge Creek into the Kalamazoo River and to prevent further migration of oil into Morrow Lake. The containment strategy involved the use of control point and protective containment booming.

Containment monitoring activities were performed initially by Enbridge personnel in the

Containment Branch Monitoring Group in the Operations Section overseen by EPA personnel. In the summer of 2012, monitoring responsibilities were transitioned to the Situation Unit in the Planning Section. Monitoring was conducted from boats and over flights, but predominantly done via land-based observations. During early winter 2012, teams inspected containment sites weekly for ice buildup, debris accumulation, containment integrity, and the presence of surface oil and/or sheen. Enbridge removed, replaced, or repaired damaged or dislodged containment depending on the potential for downstream oil impacts versus the potential for damage from the response activities. Containment sites that remained through early winter 2012 were: the confluence at MP 2.00, MP 8.50 L1, MP 8.50 L3, MP 8.75 R1, MP 9.00 I2, MP 10.75 LDB, MP 11.75 L2, MP 17.00 (Rock Tenn) and the oxbow at MP 21.50.

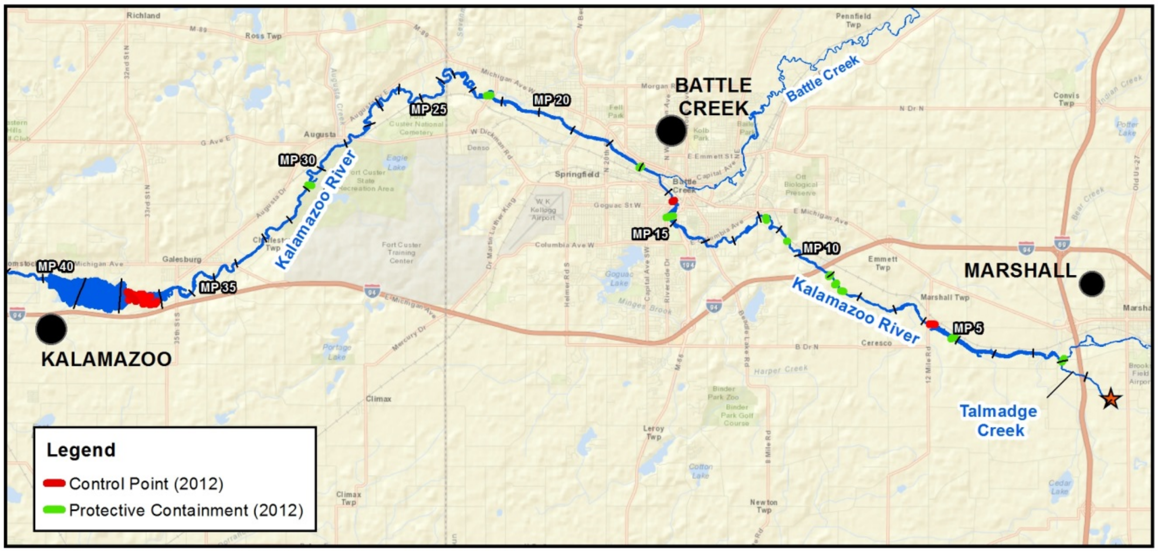
During the spring of 2012, containment monitoring activities continued. Crews observed river characteristics such as freezing, movement of flowing ice, and debris movement and continued to visually check for the presence of oil and/or sheen. The information gathered during these activities was used to determine the timing of containment deployment. Deployment of containment in spring 2012 conditions was largely dependent on fluctuating weather and river conditions. Booming activities were triggered by the absence of the potential for migration of ice and/or debris to downstream areas.

In addition to the nine containment sites monitored through the late winter, surface containment was installed at six locations (Figure 58) during the spring based on visual observations and locations where migration of sheen surfacing from submerged oil were of concern. Containment was deployed at C0.4 boat launch, Ceresco Dam, MP 14.98 I, MP 15.75, MP 30.8 LDB, and E4 control point (MP 37.75). By the end of spring 2012, containment locations remained at MP 10.75 LDB and the E4 control point.

In the summer of 2012, the control point at Ceresco Dam was redeployed and the E4 Containment System, discussed in Section 5.4.3, was installed. The surface containment boom at MP 10.75 LDB was removed since no further cleanup or maintenance action was necessary there.

Containment monitoring activities through the fall and winter of 2012 continued with observations done from boats and helicopters to visually check for the presence of oil and/or sheen, debris accumulation, and containment integrity. The Ceresco Dam control point boom was removed on December 20, 2012 due to river icing conditions.

Figure 58 - Control Point and Protective Containment Locations in 2012



5.4.3. 2012 E4 Containment System

Pursuant to the 2012 Consolidated Work Plan (Enbridge, 2011a), Enbridge re-installed control point boom at locations E4 and E4.5 to ensure containment of submerged oil and oil-containing sediments within the Morrow Lake Delta and Fan. On March 22, 2012 Enbridge commenced the reinstallation of Control Point E4 at the west end of the Morrow Lake Delta (MP 37.75); however, EPA and Enbridge began a series of discussions regarding potential benefits and limitations of Control Point E4.5.

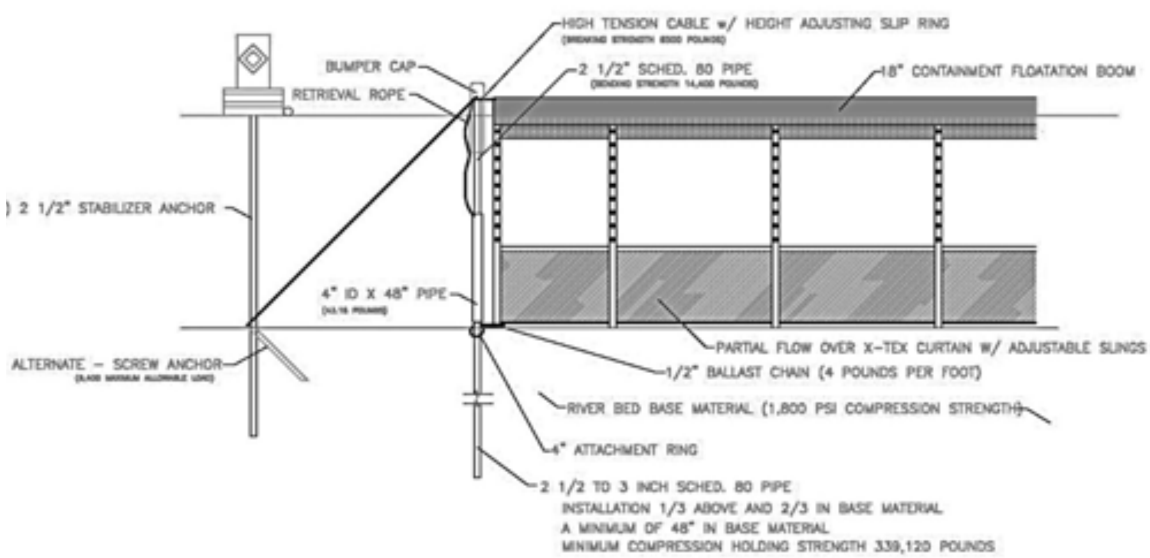
Figure 59 – E4 Containment Structure at Morrow Lake Neck (7/10/2012)

While those discussions ensued, Enbridge conducted enhanced monitoring in the Morrow Lake Delta, Morrow Lake Fan, and Morrow Lake at the direction of EPA. On March 23, 2012 Enbridge began its first round of submerged oil monitoring at approximately 40 stations in the Morrow Lake Fan, which had been established during recovery activities conducted in 2011. Enbridge also prepared the Morrow Lake Delta and Morrow Lake Monitoring and Management Work Plan (Enbridge, 2012a) to formalize the monitoring procedures in the

Morrow Lake Fan and Delta and to outline triggers for conducting submerged oil toolbox recovery activities should monitoring results indicate that containment of submerged oil was not achieved. The Morrow Lake Delta and Morrow Lake Monitoring Program is discussed in Section 5.5.

During late May and early June 2012, EPA and Enbridge met regularly to develop an alternative to the reinstallation of Control Point E4.5. Deployment of the alternative containment strategy, known as the E4 Containment System (Figure 59), began on June 22, 2012 and was completed on July 20, 2012. Construction was completed in accordance with the approved 2012 Morrow Lake Delta Alternative Containment Strategy. This new E4 Containment System consisted of an array of surface boom and half curtains in the Morrow Lake Delta and Neck. The completed system (Figure 60) consisted of nine boom segments (Booms A through F2) that used steel anchor posts, hard boom, and a partial X-Tex® sediment curtain with adjustable slings to accommodate fluctuating flow rates. A maximum flow rate of 5,000 cubic feet per second was assumed for design calculations to ensure stability and maintenance. A sediment half curtain was suspended from the booms and held to the river bottom with ballast chains. The top of the curtain was adjusted to be approximately one half of the total water depth, leaving the top half to allow water to pass through. The E4 Containment System increased the depositional properties within the Morrow Lake Delta and Fan and also allowed public use within the main channel of the delta and the boat launch for Morrow Lake.

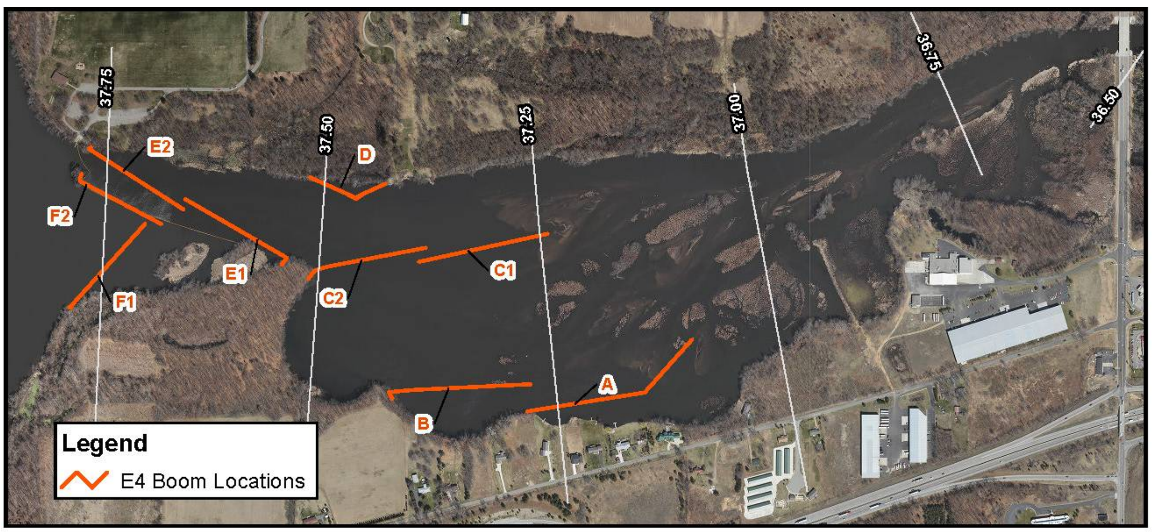
Figure 60 – E4 Containment System Schematic (Boom, Anchor, and Half-Curtain)



The E4 Containment System (Figure 61) remained in place throughout the summer and fall of 2012. Enbridge monitored the anchor systems, surface containment boom, and subsurface curtain on a daily basis for the first week following installation and continued on a regular basis to ensure the integrity of the containment system. Monitoring activities included visual inspection, video documentation of the subsurface ballast chain, and poling. Additional monitoring was completed

Figure 61 – E4 Containment System (2012)

during high flow events or other fluctuations in the water levels or velocities.



In advance of river icing, Enbridge removed the E4 Containment System on November 30, 2012 in accordance with the approved Fall 2012 E 4.0 Containment Removal Plan (Enbridge, 2012c).

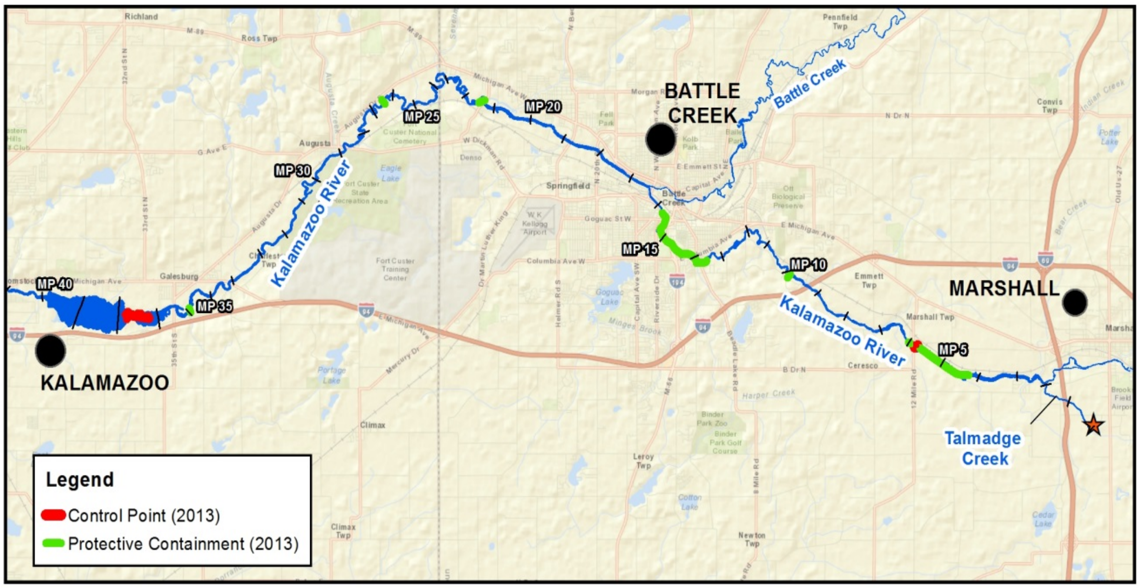
5.4.4. 2013 Containment and Recovery

In early spring 2013, EPA field observations documented recurring manifestations of oil sheen and globules within the Ceresco Dam Impoundment in areas with heavy and/or moderate submerged oil accumulations. EPA determined that containment was necessary to prevent the further migration of oil sheen and/or globules downstream of Ceresco Dam. Therefore, the FOSC directed Enbridge to reinstall containment boom at Ceresco Dam. Enbridge reinstalled the control point boom upstream of Ceresco Dam on April 27, 2013 in a double-chevron design. The Ceresco control point boom remained in place with some modifications until the dredging of the Ceresco Pilot Channel, discussed in Section 5.2.14.2, was complete. In addition to providing secondary containment during ongoing sheen management activities, the Ceresco Dam control point boom also served as primary containment when active sheen management activities were not performed.

On May 17, 2013 Enbridge installed control point boom in the channel of the South Mill Pond in response to observations of continuous ribbons of oil sheen flowing from the South Mill Pond into the main river channel. The Mill Ponds control point remained in place until August 2, 2013.

Enbridge monitored and maintained the control points (Figure 62) daily. Daily maintenance included use of skimmers to remove oily debris and sorbent material to collect oil/sheen from the control point area.

Figure 62 – Control Points and Protective Containment in 2013



5.4.5. 2013 E4 Containment System

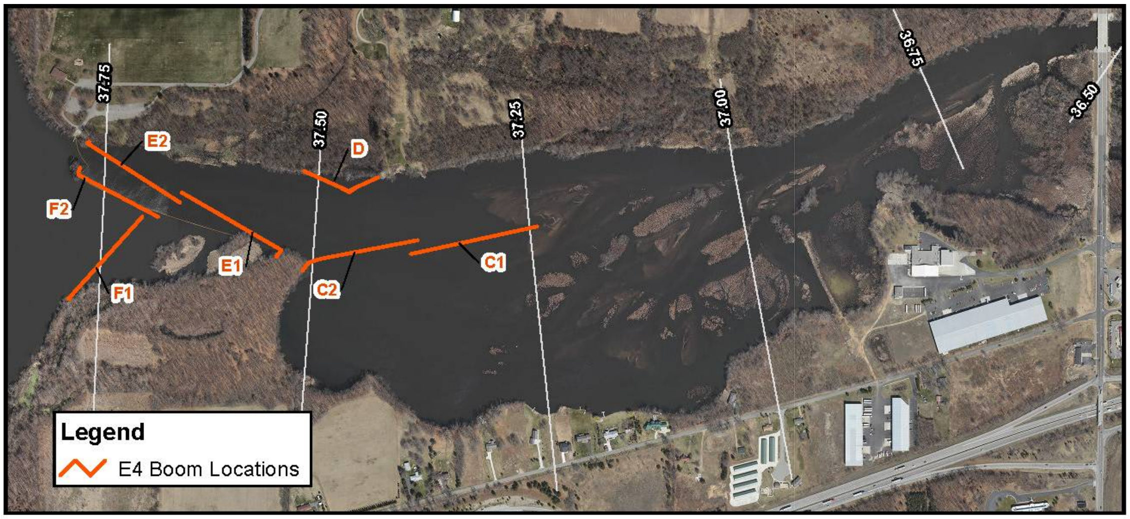
Pursuant to the March 14, 2013 Order, discussed in Section 3.2.1, the FOSC required Enbridge to re-install the E4 Containment System. After obtaining the appropriate MDEQ Permit for installation, Enbridge began installation on April 30, 2013. EPA approved Enbridge's request to not install the 2012 A and B booms in 2013, thus allowing the southern portion of the Morrow Lake Delta to remain open to the public. Therefore, the E4 Containment System (Figures 63 and 64) design was modified from the 2012 design to include seven boom segments (Labeled C through F2) rather than the nine boom segments installed in 2012. The design was also modified to utilize two-foot sediment curtain, rather than the three-foot curtain used in 2012.

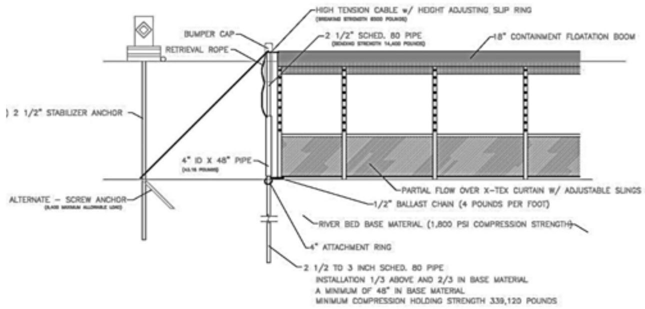
The E4 Containment System remained in place throughout the summer, fall, and early winter of 2013. Enbridge monitored the anchor systems, surface containment boom, and subsurface curtain on a regular basis. This monitoring included visual inspections, video documentation of the subsurface ballast chain, and poling. Additional monitoring was completed during high flow events or other fluctuations in the water levels or velocities.

Figure 63 – E4 Containment Structure (9/25/2013)

Prior to removing the E4 Containment System for the winter months, the FOSC required Enbridge to dredge all accumulated sediment along the sediment curtains. Enbridge hydraulically dredged sediment utilizing two separate Toyo pump and pontoon excavator setups. Dredging operations were primarily focused on sediment directly adjacent (upstream and downstream) to the E4 Containment Structure and associated heavy and moderate poling delineations. Dredging depths varied between 1.5 ft to 2 ft throughout the work area. Sediment was pumped as slurry to a processing pad at the E4 boat launch. The slurry was pumped into weir tanks and then into tanker trucks, transported to the Ceresco Dredge pad, dewatered in geotextile bags, and transported to an approved off-site disposal facility. In total, Enbridge dredged 1,982 cubic yards of sediment during the E4 Containment System removal in 2013.

Figure 64 – E4 Containment System Boom (2013)





5.4.6. FOSC Commentary on the Effectiveness of Containment Monitoring and Recovery

Containment and recovery of oil via hard and soft boom was a primary focus throughout the response. In the first few days to weeks of the response, the boom deployment was managed by numerous contractors and support agencies to get as much boom in the water as possible to help slow or prevent floating oil migration and to aid in cleanup. As the response matured, a higher degree of planning was incorporated into boom deployment, and both EPA and Enbridge utilized experts for boom design. These experts suggested changes in boom deployment configurations, which lead to a more effective booming strategy for containment and collection. Critical components of effective booming strategy included: anchor point consideration, size and type of boom, sediment curtain selection, boom deployment pattern, angle of deflection, and secure tie backs. All of these factors were utilized in this renewed wave of containment deployment to develop an effective strategy for boom use and oil collection.

Sustained focus on containment monitoring within Morrow Lake and the Morrow Lake Delta throughout 2011, 2012, 2013, and 2014 was key to minimizing migration of submerged oil beyond the delta into the lake. The deployment of subsurface containment systems in the Morrow Lake Fan, Neck, and Delta proved to be effective ways of augmenting the delta's own natural function of trapping solids migrating down the river. As such, these deployments helped ensure effective containment of oil within the delta, thus enabling its eventual cleanout during the summer 2014 dredge season. The submerged half-curtain systems, such as that depicted in Figure 64 above, also proved to be highly effective. Early use of this concept at numerous key upstream locations would have likely prevented substantial migration of submerged oil. It is strongly recommended that these half-curtain systems be considered during future similar response scenarios.

5.5. Morrow Lake Delta and Morrow Lake Monitoring

From the onset of the response, the FOSC recognized the importance of ensuring containment of submerged oil and oil-containing sediment within the Morrow Lake Delta and Fan to prevent oil from migrating downstream of the Morrow Lake Dam. It was therefore necessary to monitor the migration of oil within the Morrow Lake Delta and Morrow Lake at greater frequencies than the formal submerged oil reassessments discussed in Section 5.3.

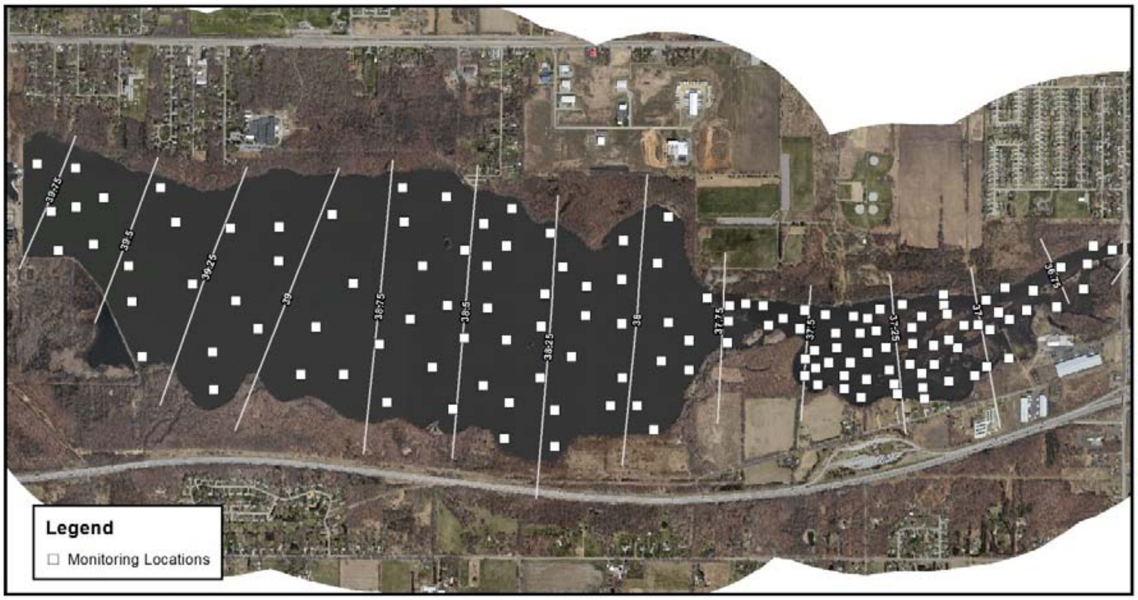
Pursuant to the approved 2011 Summer Strategic Work Plan (Enbridge, 2011a), Enbridge monitored via poling in Morrow Lake during submerged oil recovery operations in the Morrow

Lake Delta and Fan. Monitoring was conducted at 40 fixed locations, depicted in Figure 65. The cycle was completed every second day during recovery operations. Monitoring results indicated that the distribution of submerged oil in the eastern portion of Morrow Lake remained relatively constant during submerged oil tool box agitation and recovery operations.

Figure 65 – Morrow Lake Submerged Oil Monitoring Locations (2011)

The Morrow Lake Delta and Morrow Lake Monitoring program was re-implemented in the spring of 2012 to monitor submerged oil distribution and movement in the Morrow Lake Impoundment. Under direction of the FOSC, Enbridge developed the Morrow Lake Delta and Morrow Lake Monitoring and Management Work Plan (Enbridge, 2012a) to formalize the monitoring locations while developing a containment strategy for Morrow Lake, as discussed in Section 5.4.3. Initially, monitoring was conducted at 40 poling locations in the eastern half of Morrow Lake. At the end of April 2012, poling locations were added to the Morrow Lake Delta. In May 2012, additional locations were added in the western portion of the lake. Additional minor adjustments were made to the monitoring locations, as results were evaluated. The approved locations, depicted in Figure 66, included 67 locations in the Morrow Lake Delta/Neck and 69 locations in Morrow Lake.

Figure 66 – Morrow Lake and Delta Submerged Oil Monitoring Locations (2012)



Monitoring was conducted weekly from March through July 2012 and monthly from August through December 2012. Results of monitoring rounds conducted prior to the Spring 2012 Submerged Oil Reassessment identified up to seven locations of moderate submerged oil accumulations in the Morrow Lake Fan and indicated that areas of moderate and heavy submerged oil remained in the Morrow Lake Delta. After the 2012 Spring Submerged Oil Reassessment and the subsequent installation of the E4 Containment System, monitoring results did not show further migration of submerged oil into Morrow Lake. Monitoring was suspended for the season when water and sediment temperatures were below 45 °F.

Monitoring resumed in April 2013. In August 2013, an additional fixed location was added in Morrow Lake. Step-out poling was conducted in July, August, and September at locations in Morrow Lake with heavy or moderate poling results to delineate the areal extent of the submerged oil. Monitoring results throughout 2013 did not show further migration of submerged oil into Morrow Lake. Monitoring was suspended for the season in October 2013 when temperatures dropped below 45 °F.

5.5.1. FOSC Commentary on the Effectiveness of Morrow Lake Delta and Morrow Lake Monitoring

Systematic monitoring of submerged oil within the Morrow Lake Delta and Morrow Lake ensured that good situational awareness of oil presence and movement was always at hand and facilitated understanding of submerged oil movement in these areas. When considered along with other lines of evidence (sheen mapping, forensic chemistry, geomorphological prediction, and modeling) over an extended time period (2011-2014) and under different weather and flow scenarios, endpoint strategies for submerged oil containment and recovery came into focus.

5.6. Monitoring Downstream of Morrow Lake Dam

Under direction of the FOSC, Enbridge conducted seasonal monitoring via poling downstream of the Morrow Lake Dam to identify whether submerged oil and/or oil-containing sediment had migrated downstream of the dam.

Poling activities were conducted in May, August, and December 2012. During the May poling event, two locations of light submerged oil were identified downstream of Morrow Lake Dam. Light poling results were observed in the cove along the left descending bank directly downstream of the dam and at a small stream confluence downstream of the Comstock Power Drive Bridge. Additional poling around these two light locations was conducted to determine the areal extent of submerged oil. In all, eight light poling locations were identified. Sheen samples were collected and sent to an approved laboratory for chemical fingerprinting analysis. Analytical results indicated that an insufficient quantity of sheen was present to determine if the oil was Line 6B oil.

During the August and December 2012 poling events, Enbridge did not have access to the cove along the left descending bank in which the majority of light submerged oil was identified in May 2012. This was due to restrictions from the Federal Energy Regulatory Commission. No areas of submerged oil were identified during these poling events.

Poling activities were conducted at 95 predetermined locations in May, July, and September 2013 downstream of Morrow Lake Dam. During the May poling event, three locations of light submerged oil were identified. Light poling results were observed at a small stream confluence downstream of the Comstock Power Drive Bridge and at the oxbow downstream of River Street and upstream of King Highway. A sheen sample was collected and sent to an approved laboratory for chemical fingerprinting analysis. Analytical results indicated that the sheen was not Line 6B oil. During the July poling event, one location of light submerged oil was identified; however, a sufficient quantity of sheen was not present for sample collection. No areas of submerged oil were identified during the September 2013 poling event.

5.6.1. FOSC Commentary on the Effectiveness of Monitoring Downstream of Morrow Lake Dam

Ultimately, the iterative systematic monitoring for the presence of submerged oil below Morrow Lake Dam resulted in a large empirical data base supporting and documenting the conclusion that the response objectives and efforts to prevent oil from substantively migrating beyond the lake and not beyond the dam had been successful. This work was not encouraged or supported by the dam owner, who cited the federal regulatory authority for their operation as a reason to refuse, limit, or delay access. The dam owner, who also owned the upstream Morrow Lake and Delta bottom land, also limited containment options available to Enbridge (e.g., limitations on boom attachment points, seasonal limitations on boom deployment).

5.7. Sediment Trap Program

In the spring of 2012, the FOSC required Enbridge to use passive sediment collection at depositional areas, or sediment traps, throughout the affected system. Enbridge established the Sediment Trap Program to allow submerged oil recovery to continue in a minimally invasive manner. The river system transported submerged oil to natural or enhanced sediment trap locations, where it accumulated. Enbridge removed submerged oil from the sediment traps via dredging or excavation, as necessary. This passive recovery strategy complemented the 2013 EPA Order requirement for the dredging recovery program for submerged oil within the three major impoundment areas of Ceresco, the Mill Ponds, and Morrow Lake.

5.7.1. Selection of Locations and Construction

Various geomorphic settings along the Kalamazoo River were identified as preferential to the deposition of submerged oil and/or oil-containing sediment. These settings included riparian wetlands, oxbows, flood chutes, cut-off channels, backwaters, point bars, deltas, and impounded areas. Evaluation of such geomorphic considerations is important for proper sediment trap site selection and design (Figure 67).

Figure 67 – Oil Transport and Deposition in Riverine Geomorphic Setting

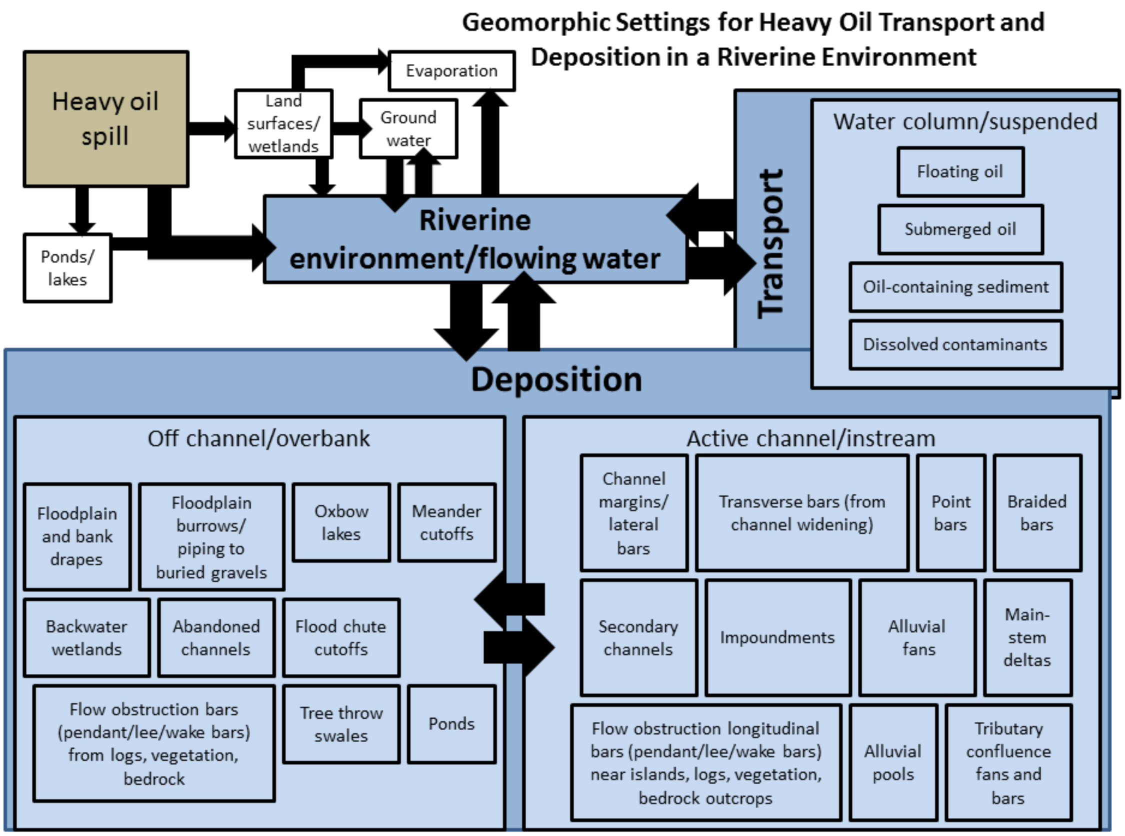


Figure 68 – Sediment Trap at MP 14.75 (9/12/2012)

Based on the results of sediment fate and transport studies, preliminary hydrodynamic modeling, and previous assessment activities, 25 sites with varying geomorphic settings were initially identified as potential sediment trap locations (see Figure 68 for example). The potential locations were further evaluated, and 16 in-channel sediment trap locations were selected (Table 6). In addition, one overbank trap location was identified (MP 11.79 LDB), which consisted of an impacted overbank floodplain area where no recovery activities had occurred due to the existence of a high-quality wetland.

Table 6 – Geomorphic Settings of Sediment Traps

Designated Sediment Trap	Geomorphic Setting
Ceresco	Impoundment
MP 10.4 N	Backwater
MP 10.5 L2	Backwater
10.75 LDB	Side channel
14.75 RDB	Side channel
19.25 LDB	Side channel
21.5 RDB	Oxbow
26.00 RDB	Backwater/Tributary mouth
28.25 RDB	Oxbow
30.80 LDB	Backwater
33.00 A	Backwater
33.00 B	Backwater
36.10 NW	Side channel
Delta A	Impoundment/Oxbow
Delta Z	Impoundment/Backwater
Delta 37.75	Impoundment/Side Channel

Each in-channel site was evaluated using hydrodynamic modeling to determine if a partial bottom obstruction, or structure, would enhance trapping and settling capabilities of the existing depositional area. Upon completion of the evaluation, six in-channel sediment traps were selected to have tree structure enhancements installed (Table 7). The structures consisted of conifer trees (Figure 69) placed in-channel and below the water surface, generally at the downstream end of the depositional area. Enbridge installed these trees in two rows on the river bottom and secured them with wooden stakes and biodegradable rope.

Figure 69 – Sediment Trap Conifer Tree Enhancement Structure and CSD Monitoring Devices

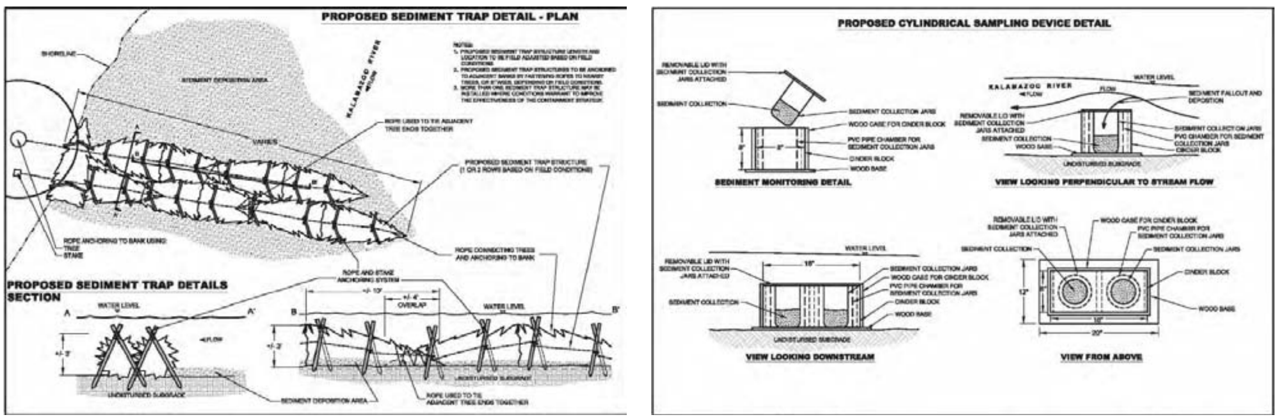


Table 7 – Sediment Trap Locations

Sediment Traps	
With Enhancement Structures	**Natural**
MP 10.75 LDB	Ceresco
MP 14.75 RDB	MP 10.40 North
MP 19.25 RDB	MP 10.50 L2
MP 26.0 RDB	MP 21.50 RDB
MP 33.0 A	MP 28.25 RDB
MP 36.10 RDB	MP 30.80 LDB
	MP 33.0 B
	Delta A
	Delta Z
	MP 37.75 Islands

In addition, upon further evaluation of the overbank trap location (MP 11.79 LDB), the FOSC determined that a structure would enhance deposition and prevent further migration of oiled sediment back to the river channel. The overbank structure consisted of a series of three coir log berms installed at the outlet of the overbank channel.

MDEQ required permits for the sediment traps. Enbridge ultimately applied for the permits in two phases. Phase I sediment traps consisting of structures and cylindrical sampling devices (CSDs) (as in Figure 69) were installed in late April and early May 2012. Phase II sediment traps were installed in September and early October 2012 in a manner similar to the Phase I sediment traps. A summary of the sediment traps installed during each phase is shown in Table 8 and depicted in Figure 70.

Table 8 – Phase I and II Sediment Traps

Phase I Sediment Traps	Phase II Sediment Traps
MP 10.75 LDB	Ceresco
MP 19.25 LDB	MP 10.40 North
MP 21.50 RDB	MP 10.50 L2
MP 28.25 RDB	MP 11.79 LDB MP 14.75 RDB
MP 36.10 North	MP 26.0 RDB
	MP 30.80 LDB
	MP 33.0 A
	MP 33.0 B
	Delta A
	Delta Z
	MP 37.75 Islands

Figure 70 – Phase I and II Sediment Trap Locations

5.7.2. Monitoring and Maintenance

Enbridge conducted sediment trap monitoring and maintenance in accordance with the approved Sediment Trap Monitoring and Maintenance Plan (Enbridge, 2012b). Monitoring included periodic CSD sampling, bathymetric surveys, and poling to monitor accumulation of submerged oil.

Enbridge also installed CSDs at each sediment trap to measure sedimentation rates in various portions of the sediment trap and to collect samples of the sediment that was depositing. The CSD consisted of two 32-ounce mason jars, mounted to a wooden box, and weighted with a concrete block. Enbridge placed between three and 10 CSDs in each sediment trap, depending on the size of the geomorphic structure. The CSDs were designed to collect data about the nature, amount, and degree of oiling of sediment deposited in the different sediment traps. Preliminary results indicate that the CSDs at most sediment traps showed relatively high rates of sedimentation under a range of high to low flow conditions, which are greater than the rates indicated for the corresponding sediment traps from periodic bathymetry monitoring. Based on the CSD results to date, as described above, CSDs provided useful information and should be considered for future responses.

The bathymetric surveys consisted of collecting measurements along transects to monitor sediment accumulation over time. Enbridge conducted poling along the same transects to monitor submerged oil accumulation. Enbridge also monitored the tree structures visually to ensure the structure was intact.

For Phase I Sediment Traps, Enbridge conducted weekly poling and CSD sampling for the first month, and then monthly, as weather conditions allowed. For Phase II Sediment Traps, Enbridge performed twice-monthly poling and CSD sampling for the first month, and then monthly, as weather conditions allowed. Poling was suspended when water/sediment temperatures dropped below 60 °F. Bathymetric surveys were conducted quarterly. Sediment trap monitoring and maintenance locations are depicted in Figure 71.

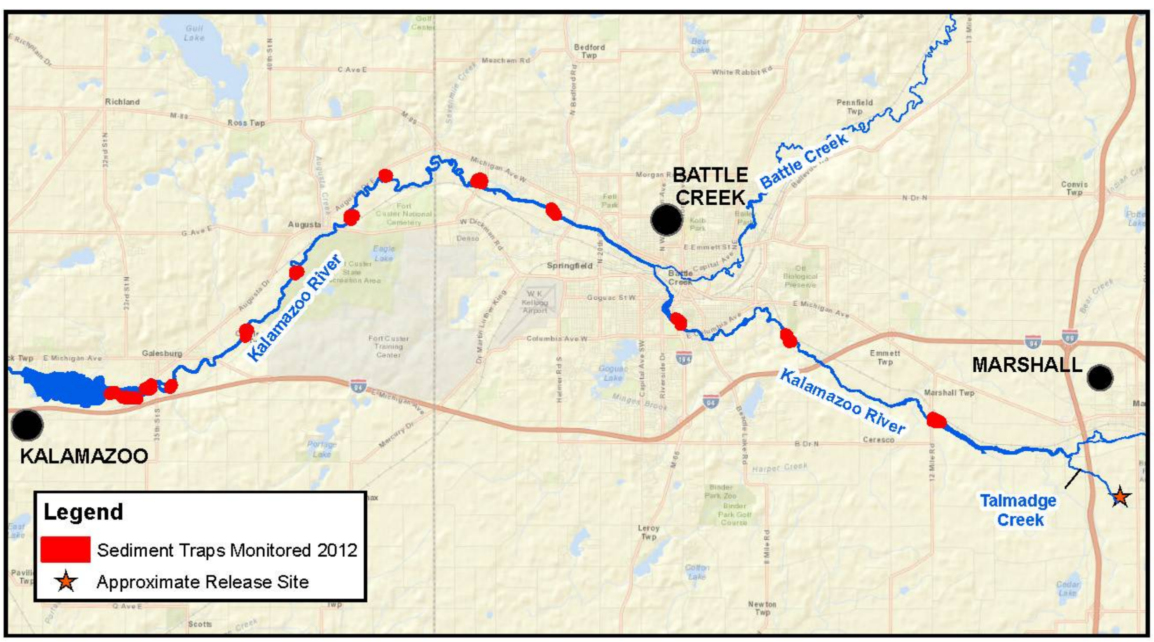


Figure 71 – Sediment Trap Monitoring and Maintenance Locations (2012)

5.7.3. Sediment Trap Oil Recovery

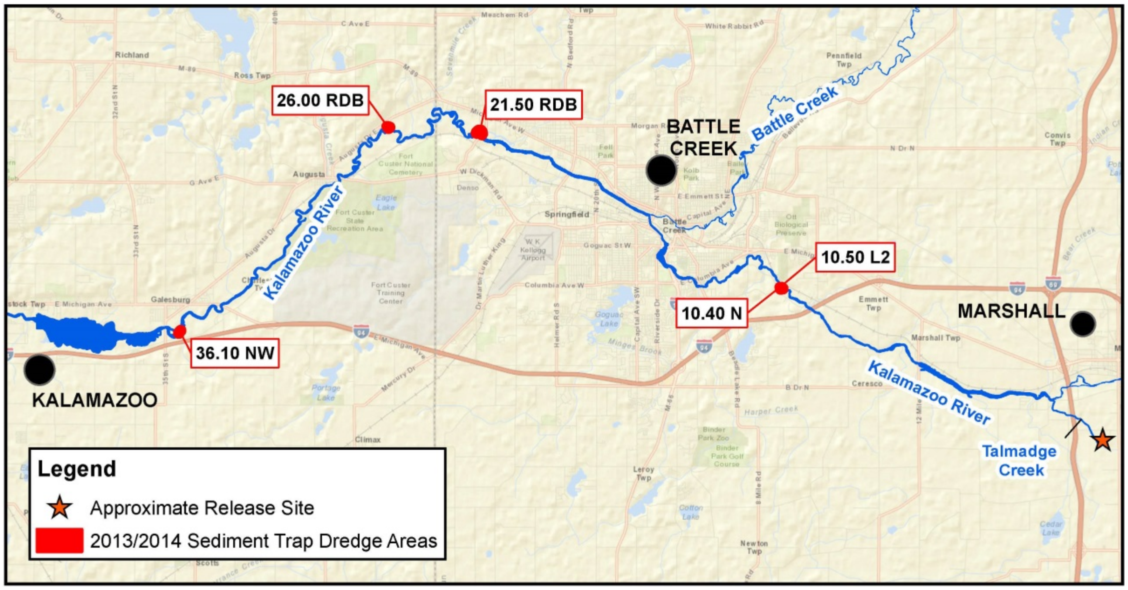
The approved Sediment Trap Monitoring and Maintenance Plan (Enbridge, 2012b) established two triggers for removal of submerged oil and/or oil-containing sediment from the sediment traps:

- Poling Trigger: When poling results within the sediment trap showed moderate and/or heavy submerged oil over 50% of the sediment trap area.
- Effective Capacity Trigger: When the trap reached its effective sediment storage capacity, where the effective sediment storage capacity reduction was defined as a 50% reduction in the cross-sectional area of the sediment trap structure as compared to the initial site survey and bathymetry.

During 2012, the MP 5.75, MP 10.40 N, MP 14.75 RDB, MP 21.50 RDB, and MP 37.50 sediment traps exceeded the poling trigger. In 2013, the MP 10.50, MP 26.00, MP 28.25, and MP 36.10 sediment traps exceeded the poling trigger. The effective capacity trigger (i.e., sediment storage capacity) was not exceeded for any of the sediment traps in 2012 or 2013.

As part of the 2013 Order, the FOSC modified the approved 2012 Sediment Trap Monitoring and Maintenance Plan (Enbridge, 2012b) to require Enbridge to dredge the sediment traps that had exceeded poling triggers. In accordance with the approved 2013 SORA (Enbridge, 2013a), the MP 5.75 sediment trap was included in the Ceresco Impoundment dredging operation, the MP 14.75 RDB sediment trap was included in the Mill Ponds Impoundment dredging operation, and the MP 37.50 sediment trap was included in the Morrow Lake Impoundment dredging operation. The remaining five sediment traps that exceeded the poling trigger were addressed individually through the Sediment Trap Program and are shown in Figure 72.

Figure 72 – Sediment Trap Dredge Areas (2013 and 2014)



Dredging or excavation activities were conducted to target depths specific to each dredge area. Under EPA oversight, Enbridge conducted post-dredge verification, in accordance with the Dredge Survey Supplement to the Sediment Dredge Depth and Area Determination Addendum (Enbridge, 2013d). A total station system was used to record bathymetric data at specific points and compare the elevations to pre-dredge data to ensure sediment was removed to the target depths, except in locations where a geologically competent layer was encountered. Once Enbridge completed sediment removal activities at a given sediment trap, it was returned to the sediment trap monitoring and maintenance program for additional monitoring.

For dredging operations at the MP 10.40 N sediment trap, Enbridge constructed a combined channel margin depositional bar and backwater geomorphic feature pursuant to the approved SORA Work Plan (Enbridge, 2013a). Enbridge used a SedVac® system (Figure 73) to remove sediment from 3 dredge areas within the sediment trap. Sediment was pumped as a slurry to a dewatering and mixing station, solidified, and transported to an approved off-site disposal facility. Water was pumped into an on-site water treatment system consisting of weir tanks connected in series with a GAC system. Treated effluent was discharged back into the river in accordance with NPDES permit requirements. Dredging was completed on August 16, 2013.

Figure 73 – Sediment Removal via Vacuum at MP 10.40 (8/2/2013)

After dredging was completed, monthly poling indicated that the MP 10.40 N sediment trap exceeded the poling trigger for removal. Dredging began for a second time in November 2013. Enbridge installed vinyl sheet piling behind secondary containment consisting of surface boom and sediment curtain. The sediment trap was dewatered, and sediment removal was conducted through excavation. Sediment was stockpiled at the east end of the dredge area, transported to the Ceresco dredge pad for processing, and shipped to an approved off-site disposal facility.

Enbridge conducted sediment removal operations at the MP 10.50 L2 sediment trap, a backwater geomorphic feature, in accordance with the approved Dredge Work Plan for MP 10.50 L2 (Enbridge, 2013e). Excavation activities began in September 2013. Vinyl sheet piling was installed behind secondary containment consisting of surface boom and sediment curtain. The sediment trap was dewatered. Water was transported via conveyance line to a water treatment system where it was treated and discharged back into the river in accordance with NPDES permit. Sediment removal was conducted through excavation. Excavated material was stockpiled into the northeast corner of the dredge area, transported to a mixing station, solidified, and transported to an approved off-site disposal facility.

In accordance with the approved Addendum to the 2013 Submerged Oil Removal and Assessment Work Plan for MP 21.50 RDB (Enbridge, 2013f), Enbridge conducted dredging operations at the MP 21.50 RDB sediment trap, a partially cutoff oxbow. Containment consisting of surface boom, turbidity curtain, and sheet piling was installed to isolate the work area. The dredge area was dewatered through the use of sump pumps and eventually a well point dewatering system. Water was pumped into an on-site GAC water treatment system and discharged into the river in accordance with the NPDES permit. Mechanical dry dredging began in October 2013 and was conducted within four separate dredge areas utilizing a hydraulic excavator. Removed sediment was transported to an on-site mixing station, solidified, and transported to an approved off-site disposal facility.

Dredging operations at the MP 26.00 RDB sediment trap, a backwater geomorphic feature, were conducted in December 2013 and January 2014 in accordance with the approved Dredge Work Plan for MP 26.00 RDB (Enbridge, 2013g). Containment boom and sediment curtain were deployed across the mouth of the sediment trap. The dredge area was isolated from the river utilizing sheet piling and sediment curtain. A Toyo pump attached to an amphibious excavator and conveyance line system was used to remove sediment from the dredge area. Sediment was pumped to weir tanks, transported as a slurry to the Ceresco dredge pad, dewatered in geotextile bags, solidified, and transported to an approved off-site disposal facility. River icing conditions and associated safety concerns prevented the completion of dredging at several points; however, EPA considered the dredging work to be substantially complete.

Dredging operations at the MP 36.10 NW sediment trap, a combined channel margin depositional bar and backwater geomorphic feature, were conducted in accordance with the approved Dredge Work Plan for MP 36.10 NW (Enbridge, 2013h). The sediment trap was isolated from the Kalamazoo River using sheet piling, boom, and sediment curtain. Sheet piled cells were used to isolate portions of the dredge area to aide in management of water. A combination of a well-point system and sumps were used to dewater cells. Water from the cells was pumped to the water treatment system, treated in a GAC system, and discharged into the Kalamazoo River in accordance with the NPDES permit. Sediment was removed from dredge areas, stockpiled, and loaded into cubic yard sacks. Filled sacks were temporarily staged on plastic sheeting within the excavation area, transported via boat to Boat Launch E3.5, and transported off-site for processing and disposal. The site was shut down for the remainder of the winter of 2013/2014 due to seasonal icing conditions.

The MP 28.25 RDB sediment trap exceeded the submerged oil trigger as set forth in the Sediment Trap Monitoring and Maintenance Plan (Enbridge, 2012b). At the request of MDEQ, the MP 28.25 RDB sediment trap was transitioned to MDEQ jurisdiction.

5.7.4. FOSC Commentary on the Effectiveness of the Sediment Trap Program

The FOSC's evaluation of multiple lines of scientific evidence (e.g., poling, fluvial geomorphology, sheen tracking, forensic oil chemistry, NEBA, hydrodynamic and sediment transport modeling) throughout 2010, 2011, and 2012 led to major impoundment dredging because the most concentrated and accessible submerged oil had accumulated in depositional areas.

The second key element of the strategy was to dredge the sediment traps located between the impoundments. This approach was both significant and effective insofar as it resulted in a distribution of recovery efforts all along the impacted sections of the river, without intrusion into all areas of impact. Exploitation of natural depositional areas, especially ones which afforded ready access by response personnel and equipment, further enhanced the effectiveness of the sediment trap program. It is believed that careful ongoing maintenance of sediment traps under state oversight will preclude the need for additional large, costly dredging of the major impoundments as conducted in 2013 and 2014.

5.8. Emerging Oil Management Program

EPA and Enbridge comprehensively monitored for, mapped, and responded to oil sheen and/or globules that appeared on the river surface throughout the affected system. Sheen appeared both spontaneously and as a result of disturbances, such as by work boats, recreational boats, or poling activities. A summary of the number of emerging oil observations in 2012 and 2013 is presented in Table 9.

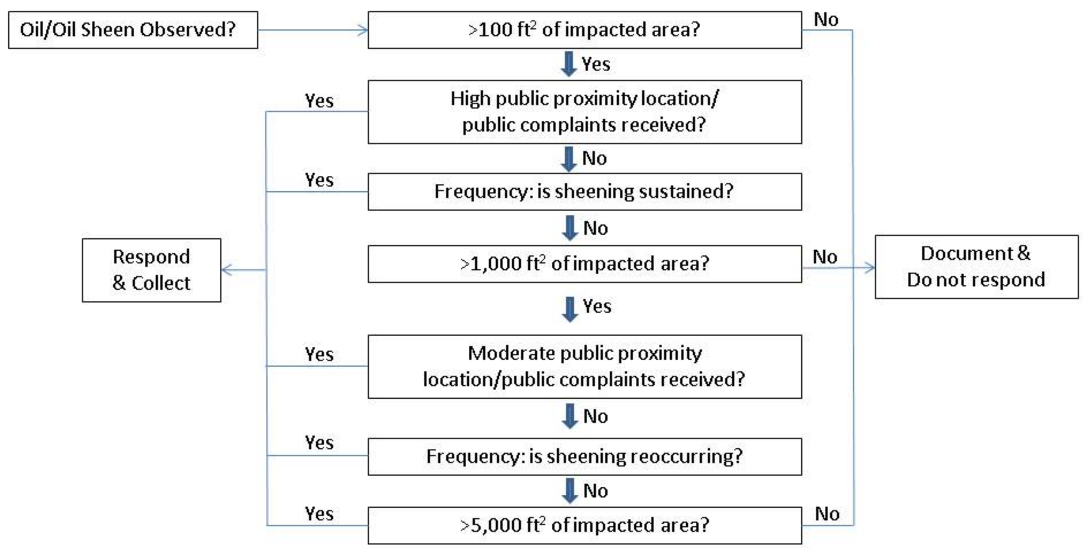
Table 9 – Emerging Oil Observations 2012-2013

	March – December 2012	**2013**
Ceresco area	169	776
Mill Ponds area	143	271
Morrow Lake Delta/Morrow Lake area	402	745
Other Locations	634	542
Total Observations	**1,348**	**2,334**

EPA, MDEQ, and Enbridge developed the Emerging Oil Management Program (EOMP) in March 2012 to address emerging oil sheen and/or globules in the Kalamazoo River system observed by operational field teams, situation overflights and ground tours, and public complaints. All observations of sheen and/or oil globules were documented on the Sheen Tracking Master Table, which included the location, type, and response actions for each observation. Results of the EOMP process showed a strong correlation between locations of moderate and/or heavy submerged oil as determined by poling and areas where oil sheen and/or globules were consistently observed on the surface of the river.

EPA, MDEQ, and Enbridge developed the EOMP Decision Flow Chart (Figure 74) to standardize the requirement for conducting responses to observations of oil sheen and/or globules. The decision process was based on the size of the affected area, the proximity to public receptors, and whether the sheen and/or globules were reoccurring in the area.

Figure 74 – Emerging Oil Management Program Flow Chart (RV 8/9/2012)



Responses were conducted at locations where sheen observation met the requirements of the EOMP Decision Flow Chart. Response teams utilized a one-inch metal sweep bar with attached absorbent pom-poms to recover surface oil. Throughout 2012 and 2013, Enbridge performed routine daily sweeping at the Ceresco Impoundment, the Morrow Lake Delta, and Morrow Lake due to frequent sheen response requests. The sweep boats with attached absorbent pom-poms were effective in collecting oil sheen and globules from the water's surface. Absorbent pom-poms consist of clusters of oleophilic fibers designed to absorb oil but not water. There were no solidifier booms deployed at any time during the response.

A secondary goal of the EOMP was to establish methods of differentiation between naturally occurring, or biogenic, and oil sheen in the response area. Four tests were developed to differentiate between the two types of sheen. Generally, four tests were conducted at each location of observed sheen.

The stick test involved disturbing sheen with a non-oiled stick (i.e., twig) and assessing its response. Biogenic sheen broke into platelets which remained separated, while oil sheen broke apart and quickly re-coalesced.

The jar shake test involved collecting sheen and water in a clear jar and gently shaking the jar. Biogenic sheen broke into platelets which remained separated, while oil sheen quickly re-coalesced on the water surface.

Figure 75 – Hexane Test (3/2/2012)

The hexane test was based on the solubility of petroleum hydrocarbons in non-polar solvents, and the non-solubility of naturally occurring biological materials in the solvents. Teams collected sheen from the water surface using a small piece of sheen net. The net was inserted into a glass vial containing hexane. The vial was shaken, allowed to stabilize, and assessed. Oil sheen dissolved in hexane causing the hexane to discolor (Figure 75), while biogenic sheen did not dissolve or discolor the hexane.

The ultraviolet (UV) test involved viewing the hexane test vials under ultra violet light. Oil sheen fluoresced, while biogenic sheen did not fluoresce.

In addition to sheen differentiation field testing, Enbridge elected to collect samples from locations where it responded to sheen in 2013. It sent samples for petroleum fingerprinting at an approved laboratory. The analytical results were evaluated against known biomarkers for Line 6B oil. Of the 111 samples analyzed, the evaluation indicated that 97 samples (or 87% of the samples analyzed) were Line 6B oil. One sample was a possible match but was mixed with other hydrocarbons, six samples were indeterminate due to low sample volume, and seven samples were not Line 6B oil.

5.8.1. FOSC Commentary on the Effectiveness of the Emerging Oil Management Program

This key element of the multiple lines of scientific evidence approach to recovery of submerged oil was significant insofar as it represented a comprehensive empirical compilation of sheen observations over the course of the response. When integrated with the GIS database developed by the project team and compared with poling data for submerged oil and forensic oil chemistry, it helped delineate and document the areas where additional action was necessary. It was paramount and absolutely central to informing the FOSC’s endpoint strategy development.

The collection of sheen samples by Enbridge to correlate them to the known chemical fingerprint of the spilled oil proved that the vast majority of oil collected was indeed from the Line 6b spill. Of the seven samples not matching the Line 6b oil, several were suspected to have different sources before sampling occurred (e.g., coming from an outfall to the river, different sheen appearance, etc.) In cases where spontaneous sheening occurred, it was almost entirely Enbridge Line 6b oil. Other contaminant hydrocarbons in the river system did not exhibit this same propensity to spontaneously sheen with little or no intrusive agitation. Thus the sampling confirmed that the Emerging Oil management Program, in conjunction with the other multiple lines of evidence, was an effective tool for the FOSC to use in responding to the Enbridge spill.

5.9. Surface Water and Sediment Sampling and Monitoring

Beginning in August 2010, EPA mobilized the Great Lakes National Program Office's (GLNPO) sampling vessel, the *Mudpuppy II* (Figure 76), for surface water and sediment sampling at Morrow Lake to determine if oil was present in the water and surface sediment. GLNPO technicians operated the vessel and collected samples daily from ten fixed stations within Morrow Lake. Sediment samples were collected using a standard Ekman bottom grab sampler. Surface water samples were collected in two-foot intervals to the lake bottom using a Niskin water bottle sampler.

In addition to the sampling conducted by EPA using the *Mudpuppy II*, Enbridge conducted surface water and sediment sampling throughout the affected reaches of the Kalamazoo River under EPA oversight, beginning on July 27, 2010. Sediment samples were collected using a Ponar dredge, bucket auger, or stainless steel spoon. Surface water samples were initially collected using Kemmerer tubes and later with peristaltic pumps. Surface water and sediment samples were collected several times a week at fixed stations from approximately 0.5 mi upstream of the confluence of Talmadge Creek with the Kalamazoo River to approximately three mi downstream of the Morrow Lake Dam.

Figure 76 – Mudpuppy II Collecting Sediment Samples (8/29/2010)

In addition to surface water sampling, Enbridge deployed real-time monitoring devices (Eureka Manta probes) to monitor for the presence of petroleum hydrocarbons in Morrow Lake.

EPA employed the surface water and sediment sampling strategy to monitor the downstream migration of oil-related compounds, to determine whether oil related compounds were settling to the bottom of Morrow Lake, and to evaluate whether oil was migrating downstream of the Morrow Lake dam. Analytical results from the surface water and sediment sampling program were provided to the health agencies for interpretation and use in their evaluations of potential river closures.

Following consultation with MDEQ, EPA authorized a reduction of sampling frequency on October 22, 2010. On August 16, 2011 EPA authorized Enbridge to discontinue weekly surface water and twice-monthly sediment sampling requirements pursuant to the EPA Order. MDEQ required Enbridge to continue a surface water and sediment sampling program, pursuant to the Sampling and Analysis Plan (Enbridge, 2011a), which MDEQ approved. As of April 2014, this program is continuing under MDEQ oversight.

5.9.1. FOSC Commentary on the Effectiveness of Surface Water and Sediment Sampling and Monitoring

The value of this early response work is represented by the fact that it allowed an initial evaluation of the discharge's immediate impact on water and sediment qualities of the affected areas of the river. It showed that contaminant loadings from the oil were not severe, while at the same time providing starting point information to assess resource impact (Natural Resource Trustees) and scope exceedance of state criteria (MDEQ RI activities).

5.10. Waste Management

Pursuant to the July 27, 2010 Order, the September 23, 2010 Supplemental Order, and the March 14, 2013 Order, the FOSC required Enbridge to dispose of wastes at EPA-approved disposal facilities; to develop a Waste Treatment, Transportation, and Disposal Plan; and to comply with other applicable regulations relating to transportation and disposal of waste generated during the response.

Waste was handled in accordance with the approved WTTDP (Enbridge, 2010). On October 28, 2010 Enbridge submitted a Supplement to the WTTDP (WTTDP Supplement), which included modifications to the list of waste disposal contractors and procedures for waste sampling in soil cells. Approved modifications were made to the WTTDP on May 20, 2011 and September 16, 2013 to address changing site conditions.

5.10.1. Waste Streams and Sampling

Major categorical waste streams generated during response activities included affected soil and sediment, oily debris, and oily water. In accordance with the approved Sampling and Analysis Plan (Enbridge, 2010), waste streams were sampled and analyzed following the protocol developed for the specific waste stream. Waste characterization was conducted on each sample to ensure proper disposal and quantify the oil contained in the waste stream.

5.10.1.1. Affected Soil

During the earliest phase of the response, Enbridge loaded affected soils onto trucks and shipped the soils to approved disposal facilities. Initial sampling indicated the soils were hazardous based on the benzene concentrations; therefore, the first shipments totaling approximately 11,000 cubic yards were manifested as hazardous waste.

After the initial soils were removed, a soil stock-pile system was implemented. Lined soil cells were constructed in Division A and at Staging Area 4 to manage excavated soils from Talmadge Creek and the Kalamazoo River overbanks. When necessary, soils were solidified. Composite samples were collected from each stock pile and analyzed to characterize the waste as hazardous or nonhazardous. In accordance with the WTTDP Supplement, every 200-cubic yard increment of excavated soil was sampled and analyzed for Total Petroleum Hydrocarbons (TPH), consisting of Diesel Range Organics (DRO), Gasoline Range Organics (GRO), and Oil Range Organics

(ORO), Oil and Grease (O&G), and percent solids.

On June 20, 2011 EPA approved Enbridge's May 25, 2011 request to transport excavated soils directly to the appropriate landfill. On June 23, 2011 the site at Division A was closed and stopped receiving additional materials. Enbridge set up a new stockpiling area at Frac Tank City for use as necessary. Affected soils were either stockpiled at Frac Tank City or directly transported to the landfill for the remainder of the response.

5.10.1.2. Oily Debris

The oily debris waste stream included sorbents, boom, pads, plastic, personal protective equipment, vegetation, and timber mats. Oily debris was stored in lined roll-off containers. Initially, the containers were transported to soil cells in Division A, where the oily debris was either mixed with soil or managed in separate cells. The stockpile of debris or soil/debris mixture was sampled prior to shipment for disposal. Beginning on November 8, 2010, roll-off boxes were transported directly to the landfill for disposal.

During the initial phase of the project, the debris was classified as hazardous waste based on its high levels of benzene. As the response progressed, the results of representative composite sampling indicated that the oily debris was non-hazardous. Samples were collected and analyzed from every fiftieth roll-off container to ensure that the waste stream had not changed. On August 29, 2011 EPA approved the discontinuation of waste characterization sampling for the oily debris waste stream, and future debris was considered non-hazardous.

Sampling to determine the quantification of oil contained in the waste stream was conducted in accordance with the approved Roll Off – Debris TPH and QAQC Waste Characterization Sampling Plan (Enbridge, 2010). In accordance with this plan, samples were collected for TPH (DRO and GRO) analysis at a minimum ratio of one sample per 10 roll-off containers. In September 2010, sampling methods were revised to include TPH (DRO, GRO, and ORO), O&G, and percent solids for every 200 cubic yards of material estimated to be within the soil/debris stockpile.

5.10.1.3. River Sediments

Enbridge dewatered the dredged sediments in geotextile bags at dredge pads near the dredging activities in the river. Dewatered and solidified sediments were transported directly to the appropriate landfill for disposal. In accordance with the WTTDP Supplement, geotextile bags were sampled and analyzed for TPH (GRO, DRO, and ORO) and O&G. All dredged river sediments were transported as non-hazardous waste to approved off-site disposal facilities.

5.10.1.4. Oily Water

From the onset of response actions through October 13, 2010, Enbridge recovered oil/water mixture from the Kalamazoo River and Talmadge Creek and directly transported it by tanker truck to an aboveground storage tank at its Griffith, Indiana pipeline facility. As the response progressed, efforts were made to reduce the amount of water being sent to Griffith by allowing the oil to separate from the water in frac tanks prior to shipment of the oil fraction. A hot oiler system was used with the frac tanks to promote further separation. From July through October

2010, 2,171,813 gallons of recovered oil/water mixture were transported to Griffith, where the oil was allowed to further separate from the water. The water fraction was managed as a hazardous waste, and Enbridge reused the oil fraction.

Enbridge initially utilized an electronic tank gauging system to report the volume of oil being offloaded at Griffith. Following an EPA audit of tank data, EPA directed Enbridge to base its estimate on the volumes of oil and water delivered by each tanker truck to enhance EPA confidence in the volume measurements. The oil volume was calculated using the oil/water mixture volume of each tanker truck and the net standard volume of sediment and water determined using the American Petroleum Institute standard centrifuge test method. The estimated volume of oil received by Griffith totaled 766,288 gallons.

Approximately five weeks into the spill response, a carbon-treatment system was set up on site to treat the water so that it could be discharged to a publicly owned treatment system. The carbon-treatment system effectively captured the benzene and the resulting wastewater was non-hazardous. The carbon-treatment system influent and effluent were sampled at an interval of once every 100,000 gallons and analyzed for TPH (DRO, GRO, and ORO) and/or O&G analysis. The carbon-treatment system was shut down on October 29, 2010 when the response transitioned from initial gross oil removal to targeted submerged oil and overbank recovery operations.

In addition to water separated from the recovered oil, wastewater was generated from the decontamination of equipment. This water was collected in small tanks at numerous locations along the site and transported in vacuum trucks to Frac Tank City.

Precipitation runoff was primarily collected in sumps from work areas, including but not limited to Frac Tank City and active or inactive dredge pads.

At the peak of the spill response operations, there were approximately 200 frac tanks on site. All but a few of these were staged in an area referred to as Frac Tank City (Figure 77). Vacuum trucks were used to transfer material in and out of the tanks. The approved Frac Tank Secondary Containment Plan (Enbridge, 2010) established best management practices and administrative controls for secondary containment at frac tank staging areas.

Figure 77 – Frac Tank City, adjacent to I-69 (8/24/2010)

Wastewater generated from Frac Tank City operations was sampled when approximately 100,000 gallons had been processed. The samples were submitted to an approved laboratory for TPH (DRO, GRO, and ORO) analysis.

5.10.1.5. Oil/Water Mixture at Stockbridge, Michigan

Line 6B was hydrotested as part of the pipeline restart process. The hydrotest generated approximately 2.5 million gallons of oil-contaminated water. This water was stored in Tank 80 at Enbridge's Stockbridge Terminal. Analytical results demonstrated that the contaminated water was hazardous for benzene. The water was shipped as a hazardous waste to an approved off-site disposal facility. Shipments concluded in December 2010. Hydrotesting water was not included in recovered oil calculations.

5.10.1.6. Miscellaneous Small Quantity Waste Streams

Miscellaneous small waste streams, including used oil, batteries, and lab samples, were generated throughout the response. These wastes were primarily stored in drums, characterized individually, and disposed of at approved facilities.

5.10.1.7. Trash

Non-oily trash generated at field locations was managed in lined yard roll-off boxes and transported directly to the disposal facility. Trash was not sampled and was not included in recovered oil calculations. The non-hazardous designation for the trash was based on generator knowledge.

5.10.1.8. Solidification

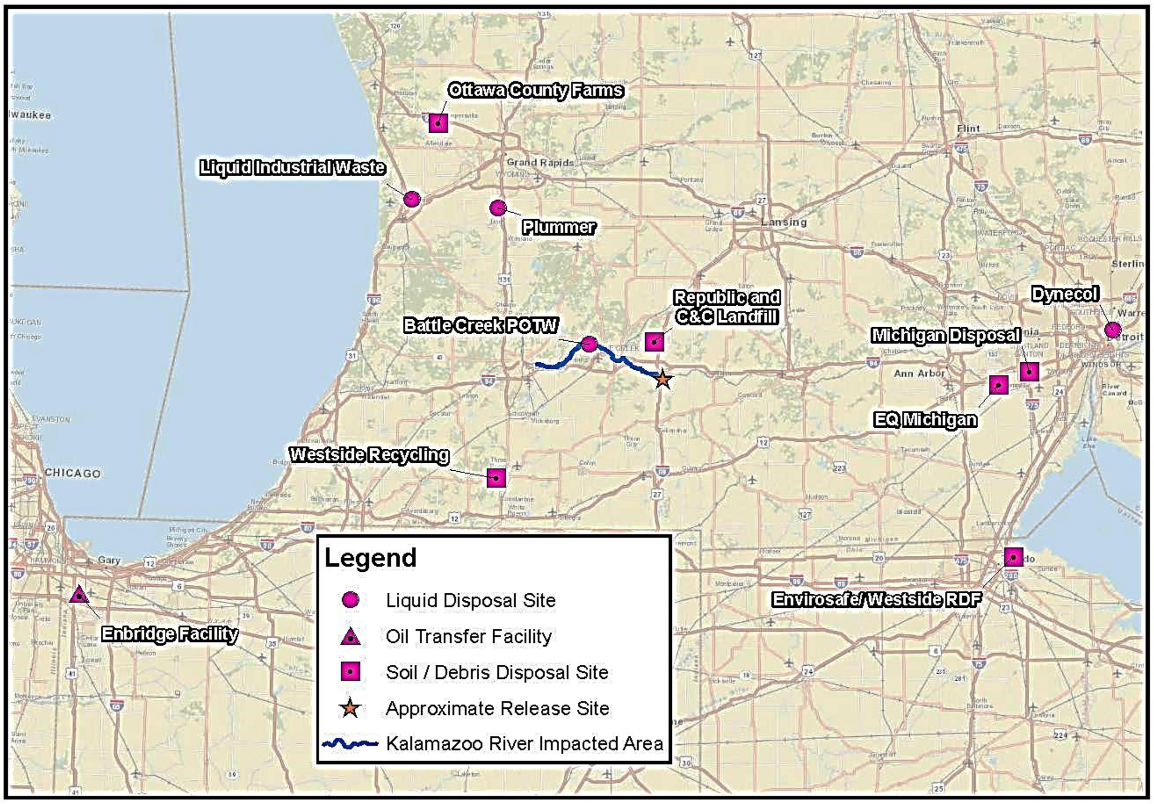
In accordance with the WTTDP, no free-flowing liquids were placed into trucks or roll-off boxes. Some of the soil and sediment generated as part of the spill response required solidification prior to shipment. These materials were solidified using approved solidification agents, including wood chips, soil, sawdust, and ash.

5.10.2. Transportation and Disposal

In accordance with the WWTDP, Enbridge requested a compliance check from EPA to assess each potential disposal facility's compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Off-Site Rule[1] prior to shipping material to a disposal facility. In accordance with the WTTDP, Enbridge submitted a weekly written report to EPA documenting the cumulative amount of each waste stream shipped.

Hazardous or non-hazardous waste manifests were used for the shipment of each respective type of waste to off-site disposal facilities (Figure 78). Returned manifest copies from the disposal facility were matched with the original manifest copies and are required to be maintained by Enbridge for a minimum of five years. The Manifest Tracking Table was developed to record manifest information. Enbridge regularly provided EPA with copies of the Manifest Tracking Table and electronic copies of manifests, and copies of hazardous waste manifests were sent to the MDNR.

Figure 78 – Disposal Facility Locations in Michigan and Indiana



5.10.3. Recovered Oil Tracking

[1]Despite oil being excluded from RCRA regulations, disposal facilities are required to characterize influent waste streams for hazardous characteristics. Some waste streams had benzene concentrations that required disposal as hazardous waste. This requirement was based on the permit requirements of the disposal facilities.

On August 7, 2010 the FOSC directed Enbridge to provide EPA with an estimate of the cumulative volume of oil recovered during response activities. On August 7, 2010 EPA approved Enbridge's Oil Recovery and Oil Debris Disposal Plan (Enbridge, August 9, 2010) that addressed methods for complying with the directive.

Under the direction of EPA, Enbridge developed the Oil Recovery Estimation Report. This weekly report included recovered oil (free product) and waste streams generated through removal actions, including affected soil, sediment, oily debris, and oil/water mixture. EPA and Enbridge developed formulaic procedures for the quantification of recovered oil from the various waste streams. These methods utilized laboratory analytical results (TPH) in conjunction with raw data, including volumes and/or weights of wastes. The estimated quantity of recovered oil by response year and by waste stream is shown in Table 10. This estimate only includes recovered oil and does not consider product lost through evaporation, natural attenuation, or otherwise not captured.

Table 10 – Estimated Quantity of Oil Recovered in Waste Streams

Waste Stream Containing Recovered Oil	**Estimated Oil Volume in Waste Stream (gallons)**					
	2010	**2011**	**2012**	**2013**	**2014 (Through 2/17)**	**Total**
Soil, Sediment, and Debris	305,559	20,498	2,431	31,403	990	360,881
Water	47,821	6,507	56	6	1	54,391
Oily Water to Griffith	766,288	0	0	0	0	**766,288**
Total	**1,119,668**	**27,005**	**2,487**	**31,409**	**991**	
Total Estimated Recovered Oil Volume						**1,181,559**

EPA is reviewing the estimates of the Line 6B oil volumes recovered from each waste stream to assess the potential for overestimation or underestimation. For example, recovered oil volumes do not account for diluent volatilization. In contrast, recovered oil volume from certain waste streams may be overestimated if the analytical methods do not differentiate Line 6B from pre-existing constituents in the environmental media sampled. As of April 2014, the evaluation of this topic had not been completed. Residual oil volume calculation is discussed further in Section 8.6.

5.10.4. Decontamination

Figure 79 – Boat Decontamination at C0.5 (12/11/2010)

Multiple decontamination methods were utilized during the response, including power washing, EPA-approved cleaning agents, chemical wipes, and dry decontamination methods. At the peak of the response as many as 94 pieces of heavy equipment, 102 vacuum truck and tankers, 126 frac tanks, and 267 watercraft were involved in the response efforts. Accordingly, decontamination areas were required throughout the entire response area. Satellite decontamination stations were established along the affected reaches of river at locations where boom was deployed, at boat launches, and at overbank work areas. By the end of October 2010, Enbridge consolidated the satellite decontamination locations into three locations located at the soil staging area in Division A, Talmadge Creek Yard 4 Staging Area Cell 12, and the C0.5 Decontamination Pad (Figure 79). These locations operated until December 2010, when a winterized decontamination area was built in Frac Tank City. The decontamination pads located within Frac Tank City operated as the primary decontamination area through the remainder of the response. When the Kalamazoo River reopened to the public in June 2012, remote decontamination stands with Simple Green wipes were stationed at selected portage locations throughout the affected area of the Kalamazoo River. These helped to ensure that members of the public who encountered incidental oil residuals could clean their watercraft.

5.10.5. FOSC Commentary on the Effectiveness of Waste Management

Consistent adherence to rigorous EPA requirements to carefully manage and track all waste generated by the response helped prevent recontamination of the impact area and ensured accountability on proper handling (waste characterization for transportation and disposal) by Enbridge. This effort resulted in EPA and state regulators having a high level of confidence that oil and oil-contaminated media from a 40-mi long response site were properly addressed with no spreading or other inadvertent redistribution by the response personnel and equipment. It was also critical to the integrity of the response for Enbridge to utilize disposal facilities that were in compliance with EPA's Off-Site Rule.

Enbridge's estimates of oil volume recovered compared to its estimate of oil spilled and estimates of residual volume (mass balance) proved helpful. While volume of oil recovered is not a driver of endpoint strategy, it is a primary variable in the mass balance equation of the response and is critical to validating that the conceptual site model (i.e., what was spilled, what was collected, and what remains in the system) makes sense. This is an important concept for final response completion decision-making. It is strongly recommended that FOSCs for future large discharges with broad geographic and multimedia impact implement this process early on for the reasons stated above.

5.11. Wildlife

Figure 80 – Wildlife Veterinarian Examining Blue Heron (courtesy USFWS)

MDNR and USFWS received the first reports of oiled wildlife on July 26, 2010. USFWS advised Enbridge to mobilize professional rehabilitators and begin building rehabilitation facilities that evening. A wildlife hotline was established that night so that the public and responders could report sightings of oiled wildlife. Enbridge mobilized its contractor, Focus Wildlife, and they built the WRC, a complete rehabilitation facility, over the next several days.

USFWS developed and led the Wildlife and Environmental Assessment Branch within the Operations Section of the response's ICS. This branch provided field observations and technical assistance to EPA regarding natural resource issues; led reconnaissance, capture, rehabilitation (Figure 80), and release of oiled animals efforts; installed deterrence measures to minimize wildlife oiling and road fatalities; and provided a link between NRDA field activities and the ICS management of the overall response.

Initially, USFWS, MDNR, USDA-APHIS, and Enbridge performed daily reconnaissance for oiled wildlife, responded to hotline calls, and captured oiled wildlife when possible. In October 2010, these responsibilities were transitioned to Enbridge. Enbridge led the rehabilitation functions, with Binder Park Zoo in Battle Creek taking a major role in rehabilitation of turtles and other reptiles and amphibians. Personnel from additional zoos and volunteers also assisted in animal care and cleaning oiled wildlife (National Response Team, 2012). Releases of rehabilitated animals were coordinated among USFWS, MDNR, and Enbridge.

<u>Volunteer Management</u>

Wildlife responders received numerous offers from volunteers willing to donate their services or materials. The following series of elements were utilized to manage these donations:

- a single hotline number was established that could, among other things, direct potential volunteers and people wanting to make donations;
- hotline staff directed volunteers to the county, which had staff that compiled data on volunteers;
- the county also used an existing local “211” line to receive calls;
- hotline staff directed donations to a local church that set up a donation station near the WRC;
- wildlife operations had an internal volunteer coordinator that could get information on potential volunteers from the county, and then recruited volunteers, made sure that they received the necessary safety and job training, and managed their schedules; and
- wildlife operations staff could pick up donated items at the donation center, which prevented the WRC from being cluttered with unnecessary visitors and unorganized, voluminous, and, in some cases, unnecessary materials.

An additional description of the use of volunteers in this incident is provided in National Response Team (2012).

Colocation of EPA and Enbridge Wildlife Personnel at the WRC

In this incident, the WRC had sufficient office space and was near enough to the ICP that the agency personnel that were leading the Wildlife Branch were located directly with the RP contractors that were conducting the rehabilitation. The wildlife reconnaissance and capture teams also used the WRC as a meeting and logistic staging area.

Coordination of NRDA Field Activities with Wildlife Branch

The NRDA Trustees make decisions independently of the spill response, but the collection of NRDA data requires access to the Spill Response Area. This was accomplished during this incident by allowing the NRDA Trustees to send a liaison to the twice-daily Wildlife Branch meetings. The liaison described the work that they wished to perform within the area controlled by the spill response and what boats and operators they would require. The planners for the Wildlife Branch then added that information into the planning process, which led to the NRDA field team activities being included in the IAP. This inclusion in the IAP allowed the NRDA field teams access to the site. The NRDA field teams also received the same safety training and daily safety briefings as members of the Wildlife Branch. The Wildlife Branch was then also able to efficiently relay immediately useful information being gathered by the NRDA field teams to the Planning Division of the spill response.

Radio Communications

The Wildlife Branch relied on 800-MHz radios provided by the MSP for instant communication among field teams and the WRC. This proved to be more efficient than relying on cell phones and more powerful than other radio systems might have been.

Wildlife Capture Methods

Wildlife capture methods need to be flexible and change over time. Initially, capture may only require wearing correct PPE and picking up or hand-netting severely impaired wildlife. Over time, more sophisticated trapping methods may be needed. For this spill, hand-netting and handheld net deployment devices (Super Talon devices modified with smaller net sizes) were successful for birds. Cannon nets over corn bait were moderately successful for oiled Canada geese, though the healthy geese tended to monopolize the baited areas. Walk-in traps constructed over time were not very successful. Only four ducks were captured this way after multiple attempts with different types, arrangements, and locations of traps. USDA-APHIS used alpha-chloralose to capture oiled Canada geese but had difficulty in using this technique. It seemed challenging to provide enough of the drug to allow for a relatively quick capture while the bird was safely accessible without endangering the health of the bird. It was also difficult to coordinate the timing of this capture method with the availability of the veterinary staff at the WHC, as the dosed birds required extra care in the first 12 to 24 hours after being brought in. Modified leg hold traps placed around a bait box stocked with small bluegill sunfish worked well for capturing oiled great blue herons; however, there were experienced trappers and equipment readily available to assist if needed. For mammal trapping, contracting with an experienced local professional trapper worked very well. For turtle capture, both hand-netting from boats and the use of commercial turtle traps worked well. Basking traps constructed for this spill were not efficient in capturing turtles, at least in part because the turtles seemed to be able to escape from them too readily.

5.11.1. Affected Species

Affected wildlife species included birds, mammals, reptiles, amphibians, fish, crustaceans, freshwater mussels, and other benthic invertebrates. The following summarizes the immediate, direct impacts observed:

- Birds: 25 birds were found dead and 27 died while in care. In addition, 144 birds were captured because of being oiled and then successfully rehabilitated and released (Enbridge, 2012d). Approximately 140 birds were observed oiled but never captured. The primary species affected and captured were Canada goose (75%) (Figure 81), mallard (9%), and great blue heron (5%). The one special status species affected was trumpeter swan, listed by the State of Michigan as a threatened species.

Figure 81 – Oiled Canadian Goose Attempting to Fly

- Mammals: 40 mammals were found dead or died during rehabilitation. In addition, 23 mammals were captured because of being oiled and then successfully rehabilitated and released (Enbridge, 2012d). An unknown number of mammals are assumed to have been oiled but not found or captured. The primary species affected were muskrat (45%), raccoon (13%), and beaver (13%).

- Reptiles: 29 reptiles were found dead and 77 died during rehabilitation (Enbridge, 2012d). In addition, over 3,800 turtles (Figure 82) and 11 snakes were captured because of being oiled or injured by response work and then rehabilitated and released. A review of the data in 2013, including dates through July 13, 2013, revealed that 3,931 individual oiled turtles were captured at least once. Of those, 101 were either collected dead or died in care and the rest were cleaned and released. Some turtles were released, re-oiled, and then recaptured, cleaned, and released again: 559 individuals were cleaned and released twice, 50 were cleaned and released three times, 10 were cleaned and released four times, and three turtles were cleaned and released five times. The primary species affected were common map turtles (77%), snapping turtles (11%), painted turtles (6%), and eastern spiny softshell turtles (3%). Other species included common musk, Blanding's, eastern box, and spotted turtles. Spotted turtles are a threatened species in Michigan. One spotted turtle was collected oiled, cleaned, rehabilitated and released in a protected area.

Figure 82 - Oiled Turtles Prior to Cleaning (courtesy USFWS)

- Amphibians: 73 amphibians were collected because they were oiled or suspected of being oiled. All were released alive.

- Fish: 42 fish were found dead during fish and wildlife response operations. MDNR standardized fish health and community surveys and a USGS investigation of fish health and histopathology indicated that fish and fish communities were affected in Talmadge Creek and the Kalamazoo River following the spill (Wesley 2011, Faisel 2010, Papoulious 2014).

- Crustaceans: 17 crustaceans were collected because they were oiled or suspected of being oiled. Three were either found dead or were dead on arrival at the WRC, two died in care, and 12 were released.

- Benthic Invertebrates: Standardized surveys (Michigan Procedure 51) and other studies indicated that benthic invertebrate communities were affected in some sections of Talmadge Creek and the Kalamazoo River following the spill (Walterhouse 2011, Walterhouse 2012, Matousek 2013). Mussels were crushed by response actions (e.g., boat traffic; Badra 2011) and mussel demographics may have been affected by the spill (Woolnaugh and Parker, 2013; independent academic research, not part of agency responses or NRDA).

5.11.2. Wildlife Reconnaissance and Capture

Figure 83 – Wildlife Capture

Wildlife recovery teams (Figure 83) utilized different tactics over time as the conditions changed. In the beginning of the response, the focus was on the heavily oiled birds. Crews responded to reports from the public and response workers and were able to pick up oiled animals with handheld nets and net launchers adapted for waterfowl capture. As the heavily oiled birds were brought in for rehabilitation, the remaining birds became wary of capture teams, and crews gained more access to the river. The Branch then developed geographic response divisions to allow for efficient team deployment and systematic searching. These teams were responsible for locating, capturing, and transporting oiled wildlife. In addition, hotline teams were established, with primary attention given to hotline response, capture, and transportation of oiled wildlife.

In addition, specialty teams were used for targeting specific wildlife:

- Beaver trapping: Live traps were placed in areas where oiled beavers had been observed.
- Great blue heron trapping: Specialized padded leg-hold traps were placed around caged bait fish.
- Turtle trapping: Hand netting and baited hoop, crab, and basking traps were used.
- Waterfowl cannon netting: Baited CO_2-powered nets were operated by USDA-APHIS.
- Waterfowl walk-in trapping: Traps were constructed gradually by Focus Wildlife.
- Waterfowl alpha-chloralose sedative: This was delivered by hand feeding by USDA-APHIS.

Figure 84 – Oiled Turtles

The Wildlife Branch provided the Situation and Planning Sections with maps of where the workers found and captured oiled turtles (Figure 84) so that the Planning Section could consider this information in its targeting for submerged oil. In coordination with the UC, the branch captured turtles downstream of Morrow Dam to look for any evidence of oiling.

Enbridge developed and maintained an Oiled Wildlife Hotline that provided a single-source reporting location for members of the community and spill responders. The reports of oiled wildlife were forwarded to dispatchers in the WRC who could communicate with field crews by cell phones and/or radios. The number and typed of calls received by the hotline are depicted in Figures 85 and 86 below. The hotline number was advertised continuously during the response in 2010 by the following methods: press conferences, press releases, IAPs, flyers/leaflets, business cards, magnetic door shields, and websites.

Figure 85 – Oiled Wildlife Hotline Call

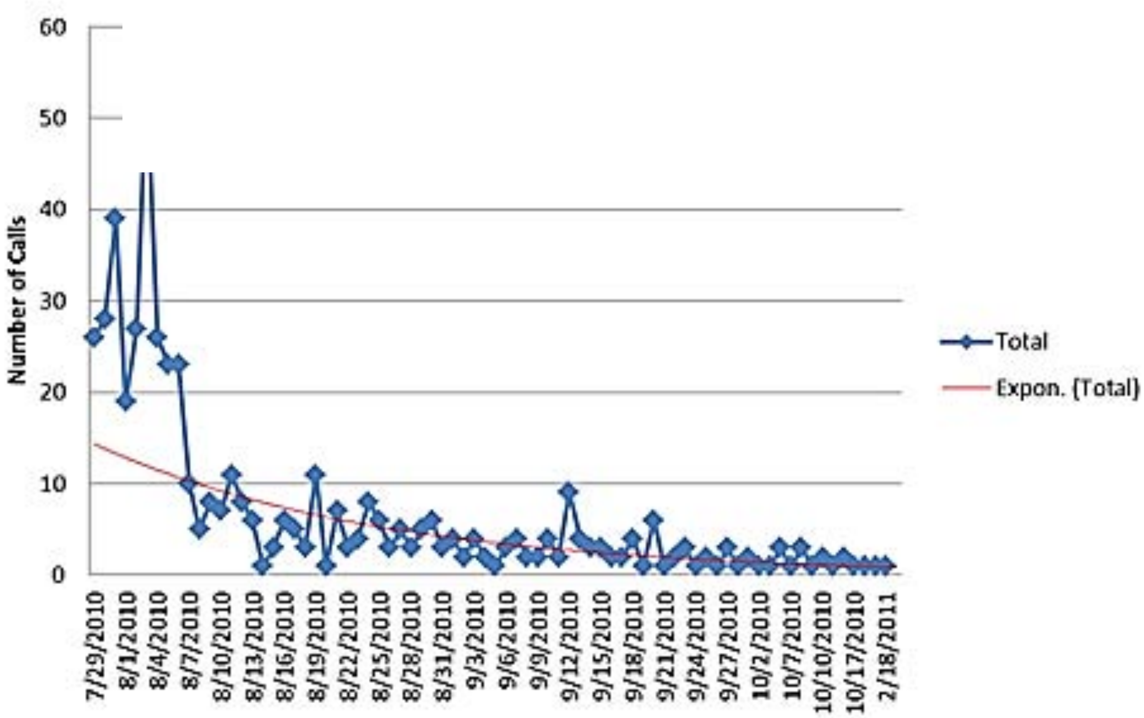
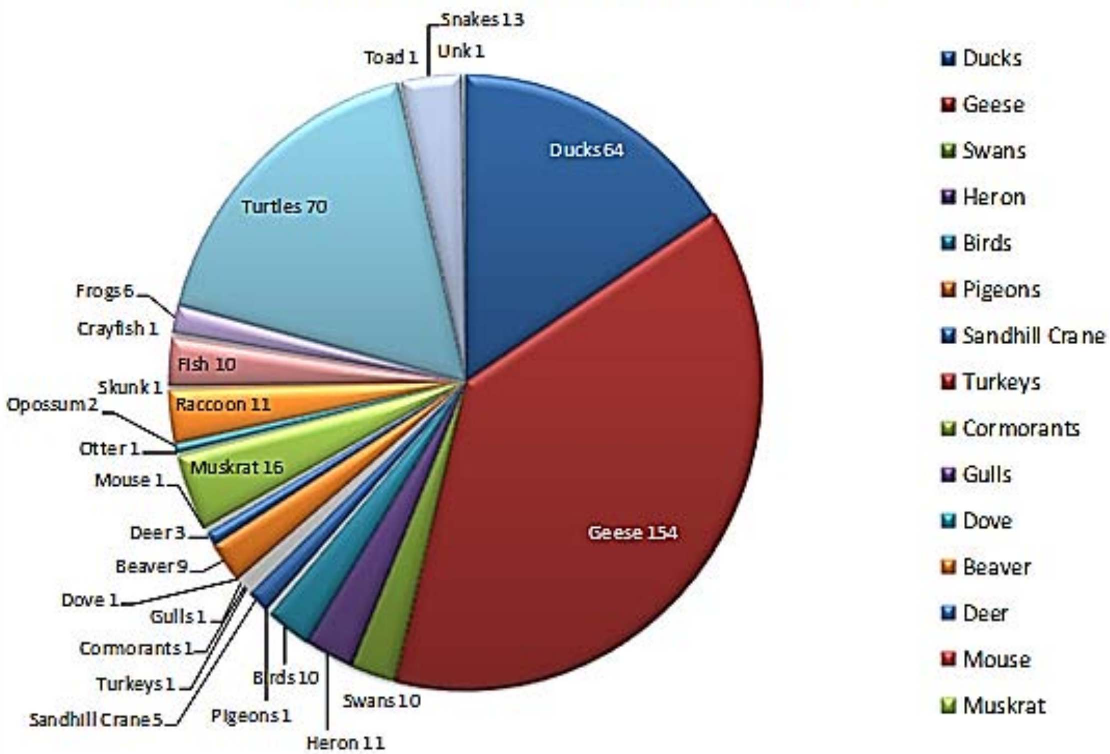


Figure 86 – Wildlfe Hotline Calls by Species



5.11.3. Wildlife Deterrence

The Wildlife Branch implemented efforts to prevent un-oiled wildlife from becoming oiled in the early days of the spill response. Deterrence crews worked on foot to construct barriers to prevent animals from entering the river. Deterrence strategies included silt fencing, snow fencing, scare tape, propane cannons, and predator scarecrows.

Field crews also placed deterrence fencing along a road that the response vehicles used heavily in order to reduce the risk to turtles after a spotted turtle was found in the area. The spotted turtle is listed by the State of Michigan as a threatened species.

After the initial few days, the response itself deterred wildlife from coming into contact with the oil with over 1,500 workers in the field, airboats, helicopters, vacuum trucks, and other heavy equipment.

5.11.4. Wildlife Cleaning and Rehabilitation

Enbridge and its contractors, Focus Wildlife and Stantec, led the wildlife care, cleaning, and rehabilitation with oversight from USFWS and MDNR. Focus Wildlife followed its Standard Operating Procedures for caring for oiled animals. This process primarily involved: intake examination, stabilization, cleaning, rinsing (Figure 87), recovery, and conditioning.

Figure 87 – Washing of a Painted Turtle Photograph Courtesy of USFWS)

5.11.5. Wildlife Release

In 2010, USFWS and MDNR coordinated the release of rehabilitated animals with Enbridge's contractors, Focus Wildlife and Stantec. In 2011 and later, turtles made up nearly all wildlife released. Stantec chose the release sites based on guidelines developed with USFWS and MDNR. Waterfowl were released in protected areas, including the Kellogg Bird Sanctuary and a remote section of the Allegan State Game Area (Figure 88). Waterfowl were banded before release with both standard USFWS bands as well as colored bands that indicated that these were birds from an oil spill and provided a phone number for more information. Turtles were released within the larger Kalamazoo River watershed, initially upstream of the Spill Response Area along tributaries to the Kalamazoo River and in the Kalamazoo River. Later, releases were near where the individual turtle had been captured in areas of the Kalamazoo River that were then considered clean.

Figure 88 – Canadian Geese Release at Allegan State Game Area (courtesy USFWS)

5.11.6. Habitats

5.11.6.1. Identification and Assessment

From August 9 through September 2, 2010, the NRDA Trustees conducted ground surveys in the Kalamazoo River floodplain to document the extent and degree of oiling in floodplain habitats (Figure 89). These surveys were conducted cooperatively with Enbridge under jointly approved NRDA work plans. The field teams walked transects that were approximately 50 meters apart from each other in floodplain habitats on both sides of the river from Talmadge Creek to Morrow Lake. Selected areas (e.g., islands, areas of heavy oiling of at least 50 square ft in the floodplain) were surveyed at a more detailed level. Field crews surveyed a total of 742 transects on both sides of the river. Field teams recorded percent of oil present on soil and vegetation, habitat type, and some habitat features (e.g. vernal pools, downed trees).

Figure 89 – Bank Erosion During 2010 Response Activities (Courtesy USFWS)

The NRDA Trustees also conducted rapid vegetation assessments in the floodplain of both the Kalamazoo River and Talmadge Creek in August of 2010 to characterize the types of habitat and vegetation present within the floodplain. The Trustees and Enbridge cooperatively developed and implemented the NRDA work plan for this rapid vegetation assessment. The results were used to inform the Trustees' comments on response-related excavation plans during the winter of 2010/2011. The Trustees and Enbridge repeated the rapid vegetation assessment in the fall of 2011 and added quantitative measurements to the study protocols. These data are being used by the State and Enbridge to inform the restoration and long-term monitoring of affected wetlands.

5.11.6.2. Protection and Restoration

The field teams engaged in wildlife reconnaissance and recovery and reported in floodplain oiling and vegetation surveys their observations on impacts of response activities through the ICS structure. Key among these observations were the first observations of submerged oil; identification of a relatively rare fen habitat type near Talmadge Creek; identification of high-value vernal pool habitats in the Kalamazoo River floodplain, along with groundwater seeps; and identification of significant bank erosion from boat traffic. These observations resulted in adjustments to response activities to minimize the harm being caused by the response or improve protection and restoration of valuable habitat features.

5.12. FOSC Commentary on the Effectiveness of the Wildlife Program

The effectiveness of this early component of the response cannot be understated. It was quickly organized and led by USFWS and Enbridge wildlife recovery and rehabilitation contractors. The experience of these groups, combined with strong Enbridge funding and a high level of community support, resulted in a quick programmatic launch and clear demonstration that a robust, professional, and government-monitored effort would ensure the success of this high-priority effort. Early success in this realm also helped engender public confidence that the response and recovery efforts would also be done properly. Much of the early media imagery and positive coverage of the success of the response were based upon the care of impacted wildlife. This launch was achieved even while efforts to assemble and develop the overall response organization and operations were still in the beginning stages.

Hotline

The ability of Enbridge to establish a public hotline within the first hours of the spill response helped tremendously in managing the public's need for information and desire to help. If an RP is not available or does not have this capability, then EPA needs to be able to set up a toll-free hotline, publicize it, and staff it. The hotline staff must be able to provide information to the callers on what to do when oiled wildlife are observed and collect pertinent information from callers for wildlife operations dispatch, volunteer coordinators, and donations coordinators. The hotline number needs to be a continuous and highly visible part of outreach to the public and in reach of the responders, including being in the IAP and handed out as a water-resistant business card. After the first week, many of the hotline calls came from response workers in the field.

Volunteers

The FOSC will ultimately receive the most volunteer requests in a response to work with or capture oiled wildlife. It is important to note that these activities be conducted by trained and permitted wildlife rehabilitation workers. Well-meaning individuals can cause harm to, or be harmed by, oiled wildlife due to lack of training and understanding of the care and precautions required when conducting these activities. Volunteer opportunities do exist, though, for people to assist in the collection and distribution of supplies and resources for the care of the oiled wildlife in support of those trained workers.

Wildlife Holding Pens

It is vital to immediately construct or obtain holding pens or cages in which oiled wildlife can be stabilized and maintained prior to washing. This allows responders to have a place to bring captured oiled wildlife immediately. The alternative is that the professional responders cannot begin the capture and stabilization of wildlife, and as a result the public may begin to capture and wash wildlife on their own. This is risky for the public, as they may come in contact with the oil and airborne constituents of the discharge and may be injured by the wildlife they are attempting to capture. There is also risk for the oiled wildlife, as they may be injured during capture, suffer from excess stress from inexpert handling and multiple transports, and receive inadequate or inappropriate treatment. In the social media era, an activist group can quickly set up a confusing and potentially risky alternative to the professional wildlife operations.

NRDA Field Staff

The NRDA Trustees make decisions independently of the spill response, yet the collection of NRDA data requires access to the Spill Response Area. The NRDA Trustees selected a liaison, who participated in the twice-daily Wildlife Branch meetings. This allowed the Wildlife Branch to incorporate NRDA field activities into the IAP. Being included in the IAP allowed the NRDA field teams access to the site.

Coordination with Local Wildlife Rehabilitators

Local wildlife rehabilitators can be crucial to a successful wildlife response, but may also attempt to mount their own independent capture and rehabilitation efforts that create unnecessary to risks to people and wildlife. This may also create challenges for proper waste disposal and animal records, including maintaining chain-of-custody for wildlife evidence. Ideally, key local rehabilitators would be involved in pre-spill planning exercises and training. Whether they have been or not, it is essential to determine who they are, contact them immediately, and invite them to help in some structured way. They can be a tremendous ally in getting accurate information to the rehabilitation and activist communities.

Wildlife Capture Methods

Wildlife capture methods need to be flexible and change over time. Initially, capture may only require wearing correct PPE and picking up or hand-netting severely impaired wildlife. Over time, more sophisticated trapping methods may be needed.

Resource Advisors (READs)

READs were not used in this spill response; however, biologists familiar with the local habitat types may have been a useful addition to Operations Teams working in the floodplain, especially when and where SCAT coverage was limited. READs might have been able to be more effective at guiding Operations Teams and ensuring that SCAT guidance and operational instructions were followed more closely. One example of this is the extent to which Operations Teams walked on oiled soils in the floodplain and stomped in absorbent materials, instead of using plywood walkways and other methods to avoid pushing the oil deeper into the floodplain soils and vernal pool sediments.

6. Safety

The unique nature and duration of this response proved to be challenging from a safety perspective. However, the safety program, as originally enacted and as it evolved, was effective and efficient. The duration of the event created many weather-related hazards due to year-round response operations. The nature of the work also included safety-related hazards associated with air toxics, boating operations, heavy equipment use, construction, and process safety, as well as working long hours over many consecutive days for weeks at a time. Despite these challenges, safety was a positive component of the response, and the injury rate was low.

The response organization embraced safety and maintained a focus on each day's events. Situational awareness was the cornerstone of the safety program. Response workers and observers alike understood the task to be done, the hazards associated with the task, and were aware of requisite protective, mitigative, and predictive measures. Workers and observers were active participants in the safety process. An aggressive incident reporting process allowed investigation, mitigation, and communication to occur on a just-in-time basis. Near-miss events received the same focus as other events and became a key component of this successful program.

Governmental response agencies and Enbridge took actions to prevent injury, illness, and hazardous materials exposure to both workers and the public. Additionally, actions were taken to ensure the safety of drinking water and fish consumption and to monitor the potential short-term and general long-term health effects to those areas and communities affected by the discharge. The Safety Officer (SO) was a critical part of the command staff established by the FOSC within the ICS structure.

Even during the first months of the response when the safety program was still evolving and over 2,000 workers were assembled to provide a cohesive response, the program is viewed as a success based on both the limited number and lack of severity of incidents reported.

6.1. Safety Organization

6.1.1. Safety Culture

At the inception of the response, EPA took a leadership role in regard to safety. This role was particularly necessary while Enbridge's safety staff became familiar with the ICS process and response safety demands. EPA safety personnel provided safety-related recommendations and observations during briefings and at other appropriate times within the ICS planning and operations cycles.

Throughout the response, and especially starting in 2011, the FOSC established that safety does not have employer or agency boundaries. This understanding was based on EPA's leadership relationship with Enbridge safety personnel, as well as field staff. This working relationship was built on a platform of positive support and actively avoided delegation of responsibility. The response safety program became increasingly stronger and cohesive as this joint responsibility for safety was embraced.

Safety stand-downs, or scheduled times for stopping response operations to allow focus on a particular safety message, were important and effective tools for providing response personnel with focused safety messages and updates. Safety stand-downs were not routine events; however, new tasks, increases in personnel, or increases in incidents (especially related to certain tasks or incident types) triggered safety stand-downs. Additionally, limited or just-in-time stand-downs were called when necessary.

6.1.2. Safety Officer

In the ICS, the SO is a command staff support function to the FOSC. The SO developed and recommended measures to ensure the safety of personnel and to monitor for and anticipate hazardous and/or unsafe situations. During the initial response phase and continuing throughout the response, the SO's major responsibilities included identification of hazardous situations, review of medical plans, development of internal safety plans, and review and acceptance of the Health and Safety Plan (HASP).

The FOSC mobilized safety and health professionals to ensure that response activities protected the health and safety of response personnel and the public. During the first several months of the response, safety personnel from OSHA, MIOSHA and USCG supported the EPA SO. Three Assistant Safety Officers (ASOs) were provided by the MIOSHA Disaster Response Team to support construction safety, general industry safety, and industrial hygiene. Three personnel from the OSHA Cleveland Area Office provided industrial hygiene support. The EPA START contractor maintained SOs who reported the EPA SO. MIOSHA was involved in evaluating worker safety issues. Federal, state, and local state health agencies were involved in evaluating community health and safety issues. These personnel worked in both administrative and field roles to ensure worker and public safety.

Following the initial response, EPA continued to fill the command safety role, while Enbridge began filling the role with personnel from its various corporate safety functional areas. This change ensured a certain amount of consistency in the SO role. Enbridge provided on-site SOs during the initial response phase for Divisions A and B and a roving SO for Divisions C/D/E. As work and time progressed, Enbridge provided more SOs for active work areas, as well as roving SOs with responsibility for river areas above and below the Mill Ponds dam.

During 2011, the safety team was augmented by two experienced safety professionals in a rotation from the START contractor. This rotation allowed for a consistent reinforcement that safety was a vital function and not an impediment to production. Simultaneously, Enbridge began a rotation of four safety professionals within its organization, while simultaneously providing field safety personnel for major tasks or functions.

In June 2011, ASOs were added to assist Command Safety Staff, primarily due to increased work at locations within the spill response area. ASO mobilization allowed for more effective oversight as operations were spread out over the length of the affected river system and specific submerged oil recovery efforts were being conducted at Morrow Lake and the Morrow Lake Delta area.

6.2. Public Health and Safety

As required under the NCP, protection of public health was a primary objective of the response actions. The FOSC worked with experts within federal, state, and local agencies to protect the public safety. Information regarding the cleanup efforts, air quality testing, drinking and contact water safety, irrigation, and livestock and wildlife affects was distributed in numerous ways, including press interviews, briefings, public meetings, print material, the EPA website, and state agency websites.

The FOSC, in coordination with state and local health and safety agencies, enacted several key actions to protect the public from the discharged oil's impacts. State and local health agencies enacted a voluntary evacuation of residential areas as a precautionary measure by using EPA-generated data. An extensive air monitoring and sampling program was developed and implemented throughout the response in areas potentially affected by the discharge. Surface water recreational usage bans, irrigation and livestock watering bans, and fish advisories were also enacted.

6.2.1. 2010 Community Air Monitoring and Sampling

The discharge of heavy crude oil blended with lighter hydrocarbon diluents (DilBit) resulted in volatilization of the diluents to the atmosphere within the surrounding area. EPA and Enbridge (under EPA direction) immediately began conducting air monitoring and sampling for the protection of public health within the surrounding communities and at response work locations. An extensive air monitoring and sampling program was developed and implemented in areas potentially affected by the discharge.

On July 26, 2010 EPA began assessing air quality conditions near Marshall and Ceresco, Michigan. This initial assessment included real-time air monitoring for total VOCs, hydrogen sulfide (H_2S), carbon monoxide (CO), percent oxygen, and percent lower explosive limit (LEL) using a MultiRAE gas monitor. Additionally, benzene readings were collected using Draeger tubes.

Figure 90 - Air Monitoring and Sampling by 51st CST Personnel (8/1/2010)

On July 27, 2010 EPA began enhanced air monitoring activities using ppbRAEs, MultiRAEs, and AreaRAEs to monitor for total VOCs, as well as UltraRAEs and Draeger tubes and chips to monitor for benzene. In addition, the 51st Civil Support Team (CST) verified benzene UltraRAE readings utilizing several mobile HAPSITE field gas chromatograph instruments. Benzene is the most toxic of the VOCs that were released from the discharged oil and was therefore used as an index parameter for real-time air monitoring.

On July 28, 2010 Enbridge initiated air monitoring and sampling activities, pursuant to EPA direction and with EPA oversight. From July 28 through July 31, 2010, both EPA and Enbridge continued air monitoring (Figure 91) and sampling (Figure 92) activities. Mobile teams monitored the communities near the affected waterways from the Source Area to Morrow Lake 24 hours per day. Focused community air monitoring and sampling occurred throughout 2010 at the Squaw Creek neighborhood in Marshall, including the portion that was evacuated; the Play Care Learning Center in Marshall; the Ceresco Dam neighborhood; and Baker Estates in Battle Creek. Beginning on August 1, 2010, additional real-time air monitoring for VOCs, benzene, and H_2S was performed along the perimeter of excavation areas in Divisions A and B. Teams returned for subsequent measurements at locations where benzene was detected by either air monitoring or sampling or at locations where odors were present.

Teams collected air samples from fixed community locations where health officials were concerned about public exposure and from locations near oil collection points (Figure 90). Samples were collected in regulated evacuated Summa and mini canisters (24-hour time-integrated and/or grab) and analyzed for VOCs using EPA Method TO-15.

On August 2, 2010 an EPA mobile laboratory was mobilized to analyze Tedlar Bag samples collected from the fixed community locations, discussed previously, and from locations where elevated benzene readings were measured with air monitors. Data from Tedlar Bag samples were used to assist local, state, and federal health agencies for making evacuation and reoccupation decisions. EPA's mobile laboratory remained on site until September 1, 2010, when Enbridge provided an on-site laboratory acceptable to EPA for continuation of the Tedlar Bag analyses. This laboratory remained on site until October 19, 2010.

Additional air samples were collected from September 30 through October 31, 2010 during dredging operations conducted at the Ceresco Impoundment. In total, 221 24-hour canister samples and three grab canister samples were collected for VOCs analysis. All concentrations were below screening levels for VOCs.

The Public Health Unit (PHU) was organized within the Planning Section of the ICS. It was comprised of MDCH, ATSDR, CCPHD, KHCS, MDNRE, the Michigan Department of Agriculture (MDA), EPA, and Enbridge. The PHU reviewed air monitoring and sampling results daily from July 31, 2010 to August 20, 2010. NOAA weather reporting was used to determine whether the air samples were collected downwind of the discharge. MDCH selected screening levels (Human Health Air Screening Levels) for crude oil-related VOCs using health-based exposure thresholds, including the ATSDR Intermediate Minimal Risk Level (MRL), the ATSDR Chronic MRL, the EPA Reference Concentration, the EPA Regional Screening Level, and the MDNRE Air Toxics Screening Level. The intermediate MRLs are protective of daily exposures lasting for up to one year (365 days) of exposure. All the other health-based values are protective of daily chronic exposures for a lifetime.

Detections measured by air monitoring equipment were often present for a short period of time ranging from seconds to minutes. The screening levels were established conservatively so that transient exposure to chemicals at or even slightly above the human health-based screening level would not be expected to increase the risk of health effects, since the screening levels were developed for continual inhalation exposure to these chemicals for much longer periods of time. The same was true for comparing analytical results from grab samples to screening levels.

Figure 91 – Air Monitoring Locations Along Affected Waterway

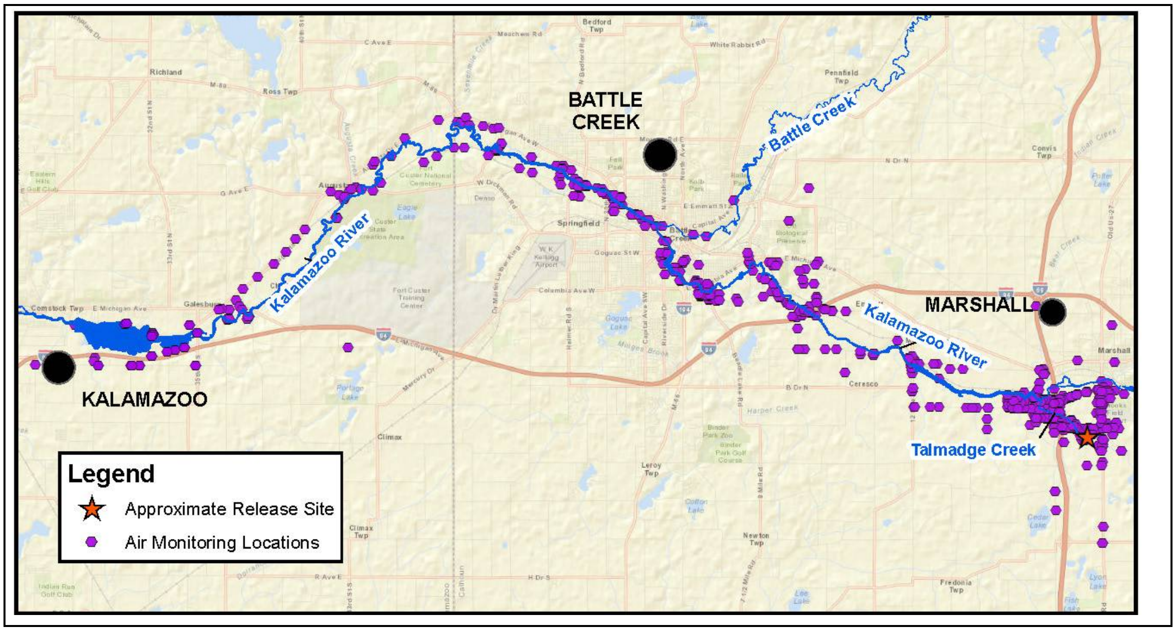
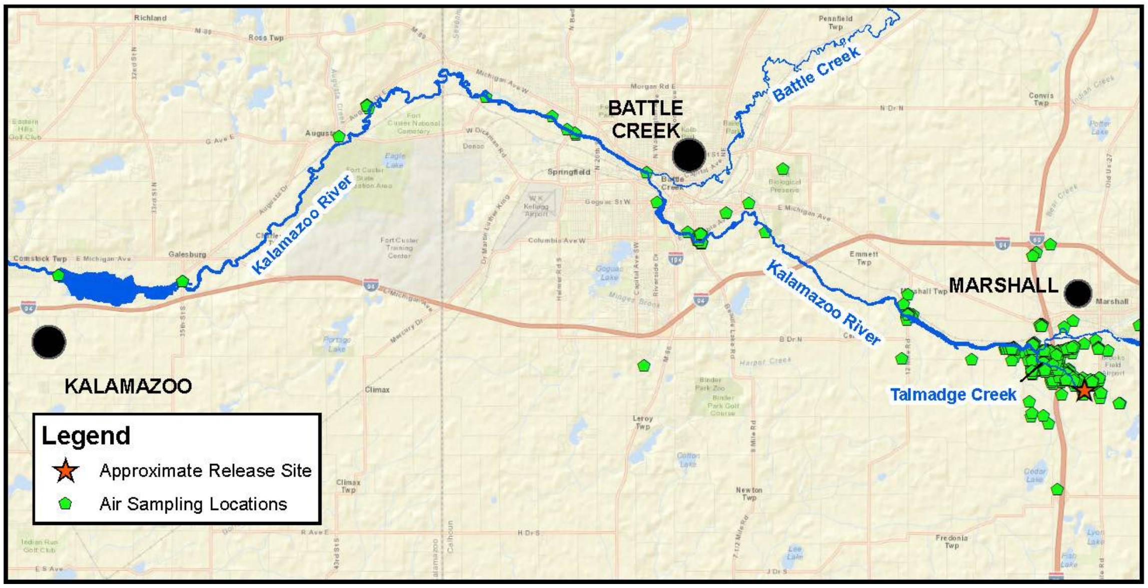


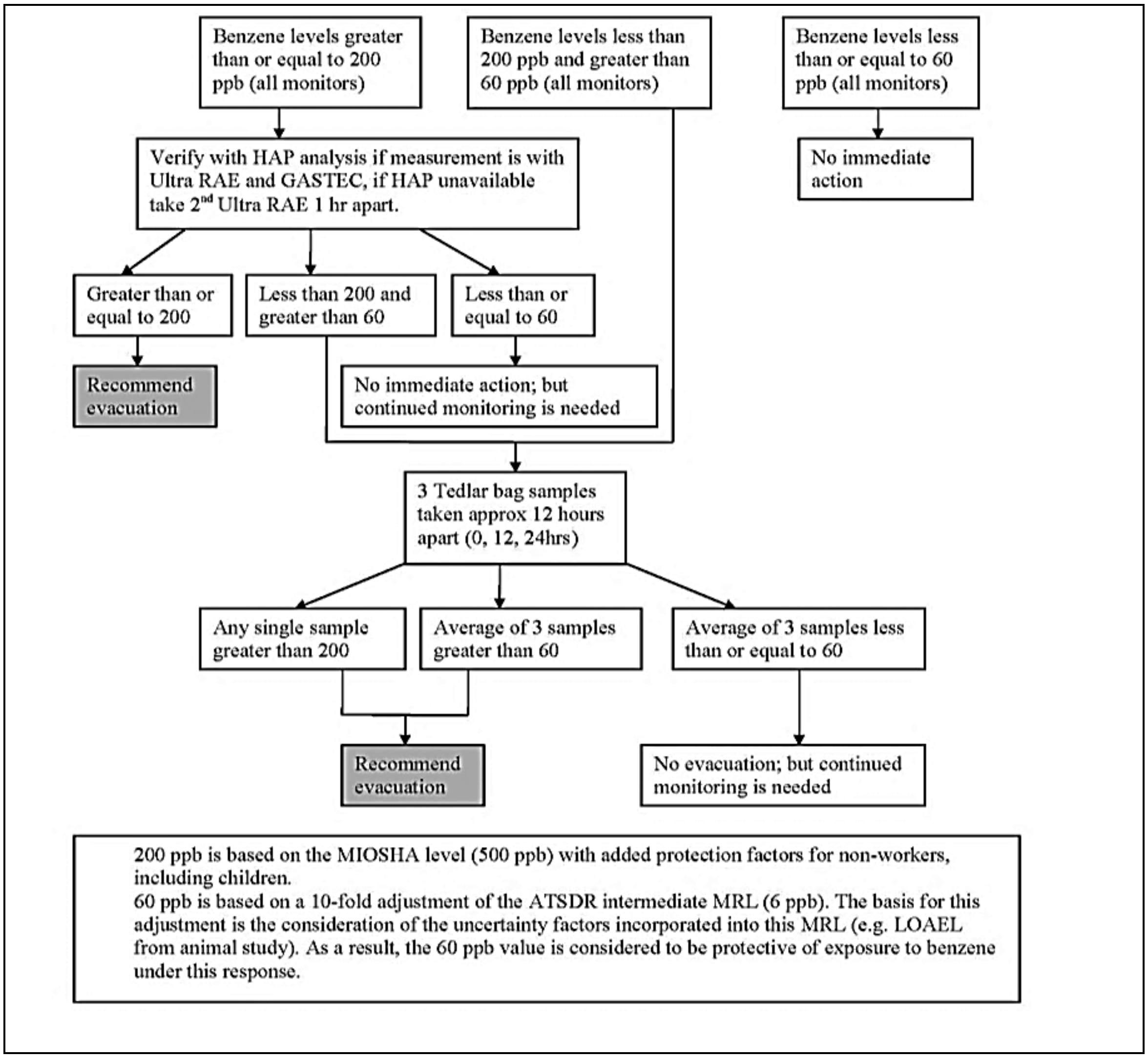
Figure 92 – Air Sampling Locations



6.2.2. 2010 Evacuations

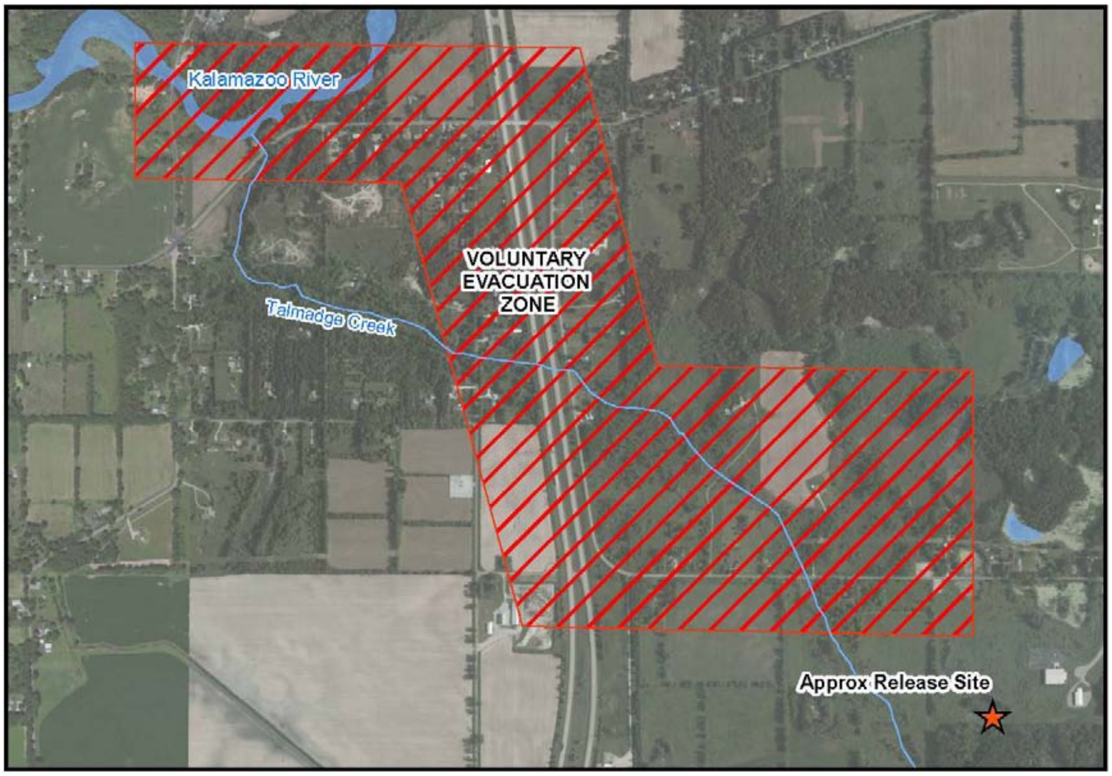
The PHU used the 2010 Human Health Air Screening Levels to develop a decision tree (Figure 93) to determine when to recommend that residents evacuate specific neighborhoods and when residents could safely return. If benzene was measured at or above 200 parts per billion by volume (ppbv) with any monitor, additional measurements were taken with a HAPSITE or multiple UltraRAE measurements one hour apart. If verification measurements were also above 200 ppbv, then an evacuation was recommended. If verification measurements were above 60 ppbv but less than 200 ppbv, three Tedlar Bag grab samples were collected approximately 12 hours apart. If benzene concentrations in any single Tedlar Bag sample were greater than 200 ppbv or if the average of three samples was greater than 60 ppbv, then an evacuation was recommended. If average benzene levels were not greater than 60 ppbv, continued monitoring was recommended.

Figure 93 – Evacuation Decision Tree (Based on Benzene Concentrations), July 2010



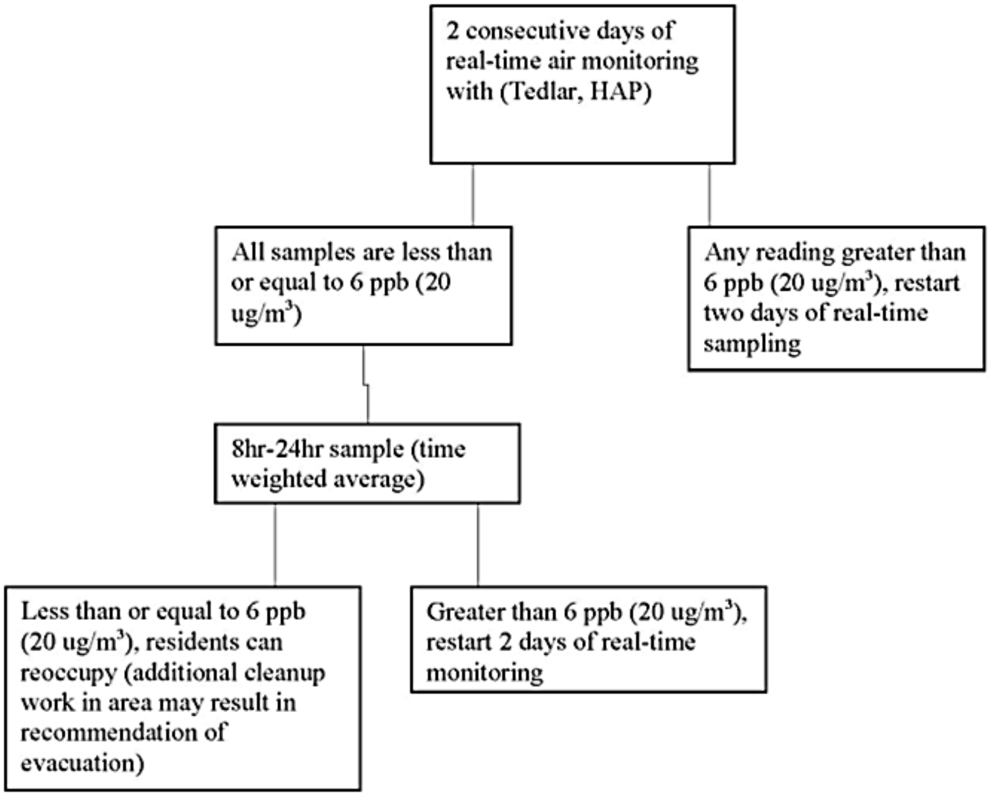
On July 29, 2010 CCPHD issued a voluntary evacuation notice for approximately 61 homes located north and northwest of the discharge location (Figure 94). KHCS, CCPHD, and MDCH issued a statement indicating that residents should avoid spending time in the immediate affected area from the Source Area to the Morrow Lake Dam.

Figure 94 – Voluntary Evacuation Zone



The Reoccupancy Decision Tree is shown in Figure 95 below. CCPHD recommended reoccupancy of an evacuated area when benzene concentrations were shown to be consistently less than six ppbv over a two-day monitoring period and confirmed with an eight- or 24-hour

Figure 95 – Decision Tree for Reoccupancy (Based on Benzene Concentrations)



summa sample.

On August 18, 2010 CCPHD lifted the voluntary evacuation. Once the voluntary evacuation notices were lifted, inspections of individual homes were conducted to determine when reoccupation could be recommended. CCPHD developed the Residential Assessment Protocol for conducting these inspections. After obtaining permission from the resident, Residential Assessment Teams conducted outdoor and indoor air quality testing of the properties. Monitoring for VOCs was conducted using MultiRAEs, and monitoring for benzene was conducted using UltraRAEs and Gastec Pumps. As part of this process, 177 air monitoring measurements were performed inside of homes before reoccupation following voluntary evacuation.

6.2.3. Community Air Monitoring and Sampling in 2011, 2012, and 2013

In June 2011, the FOSC directed Enbridge to modify the 2010 Sampling and Analysis Plan (Enbridge, 2010) to address 2011 recovery activities. In accordance with the approved 2011 Air Monitoring and Sampling Addendum (Enbridge, 2011a), Enbridge performed air monitoring and sampling within the community to assess and evaluate exposure to chemicals of concern related to the original discharge and subsequent recovery activities.

Enbridge performed air monitoring and sampling during submerged oil/sediment agitation and overbank recovery in June and July 2011. Monitoring and sampling were conducted within residential communities and at work area perimeters adjacent to residential communities near affected waterways, focusing specifically in the areas of Baker Estates and the Village of Ceresco, Morrow Lake, and at river segments planned for opening to the public.

Enbridge used real-time air monitoring equipment including MultiRAE PIDs (analyzing for VOCs, H_2S, and SO_2), UltraRAE PID (analyzing for VOCs), and Gastec detector tubes with pumps (analyzing for benzene). Community air monitoring was conducted during work activities, typically between the hours of 0700 hours and 1900 hours. In 2011, Enbridge took 9,378 real-time community air monitoring measurements, including 3,306 for VOCs, 1,900 for benzene, 2,377 for H_2S, and 1,795 for SO_2.

Enbridge, with EPA oversight, conducted air sampling at fixed locations selected to best represent likely community receptors based on wind direction, proposed work activity, and air monitoring results. Eight-hour regulated canisters were collected at work area perimeter locations, and 12-hour regulated canisters were collected at river segments planned for opening to the public. During this period, 668 air samples were submitted for VOC analysis using modified EPA method TO-15. Public health officials evaluated this data for determination of potential health impacts and to clear areas for reuse.

Portable meteorological stations were deployed in the Village of Ceresco and Baker Estates communities to collect site-specific meteorological data. Wind roses were generated from the data to provide a graphical illustration of wind speed and direction over time. Wind roses were used, in conjunction with air monitoring and sampling data, to evaluate potential exposure to contaminants of concern generated during active oil recovery activities. Additional meteorological data was collected from the Battle Creek Kellogg Airport and Marshall Brooks Field Airport.

In October 2011, following EPA's own review of the daily air monitoring and sampling data, the FOSC approved Enbridge’s request to decrease the prescribed level of air monitoring and sampling. Community air monitoring and sampling continued in 2011, 2012, 2013, and 2014 as necessary and generally focused on areas surrounding active recovery operations. This data was evaluated to ensure that local communities were not adversely impacted by the recovery operations.

Enbridge performed air sampling during overbank recovery activities in 2012 and during dredging activities within the Village of Ceresco in September and October 2013. Fixed air sampling locations were selected to best represent background conditions and potential community receptors, based on wind direction. Residential time-integrated air samples were collected over a 24-hour period. In 2012, 47 air samples were submitted for VOC analysis using modified EPA method TO-15. In 2013, 63 air samples were submitted for VOC analysis using modified EPA method TO-15. Community air monitoring was not performed during 2012 or

2013.

MDCH reviewed air monitoring and sampling data as it was generated. Until July 25, 2011, data was compared against the intermediate exposure (daily exposure for 14-364 days) screening levels for the oil-related chemicals selected in 2010. After July 2011, MDCH began using the chronic exposure (daily exposure for > 365 days) human health and screening criteria to evaluate chemical exposure.

6.2.4. Odor Responses

In August 2010, Enbridge established a public information hotline for residents to report odor issues related to the discharge. EPA and CCPHD were notified of odor complaints. Odor investigations were conducted in response to complaints received through the hotline or from the UC. The Odor Response Team conducted air monitoring using MultiRAEs and UltraRAEs and collected 24-hour and grab air samples at each location. EPA verified air monitoring readings and observed air sampling activities. Sample results from 24-hour samples were compared to the appropriate Human Health Air Screening Level.

The Odor Response Team responded to 118 odor complaints in 2010 and 2011. No odor complaints were received in 2012 or 2013.

In addition to odor complaints, this hotline also received complaints about noise and general intrusiveness of the recovery operations that were addressed by Enbridge.

6.2.5. Surface Water Recreational Usage Ban

State and federal government agencies conducted an extensive investigation into surface water contamination from the pipeline discharge. The investigation included ongoing measurements of the surface water quality and review of the presence and movement of oil within the Kalamazoo River system. Affected portions of Talmadge Creek and the Kalamazoo River were closed to the public to limit potential exposure to the oil or oil-affected media and to protect the public from ongoing removal actions.

Figure 96 – CCPHD Sign Regarding River Use Ban (7/27/2010)

As a precautionary measure, CCPHD and KHCS issued advisories to the public within days after the discharge to avoid contact with water from the Kalamazoo River until further notice. The CCPHD and KHCS also closed the affected portions of the Kalamazoo River, from Perrin Dam in Marshall to the Morrow Lake Dam in Kalamazoo County, to recreational uses including swimming, wading, fishing, boating, canoeing, and kayaking (Figure 96). The river closure remained in place throughout 2010 and 2011 while intensive recovery activities were ongoing.

Beginning in April 2012, segments of the river were opened for recreational use. A key prerequisite of river opening was the release of the Public Health Assessment (PHA) entitled "*Kalamazoo River/Enbridge Spill: Evaluation of people's risk for health effects from contact with the submerged oil in the sediment of the Kalamazoo River*" issued by the MDCH and ATSDR (MDCH/ATSDR, 2012). The primary conclusions of this report are summarized below.

1. Sediment containing submerged oil, oil remaining in floodplains and on riverbanks (such as tar patties), or sheen on the water could cause temporary health effects, such as skin irritation.
2. Repeated skin contact with and accidently eating small amounts of sediment containing submerged oil will not result in long-lasting health effects.
3. Repeated skin contact with and accidently eating small amounts of sediment containing submerged oil will not result in a higher than normal risk of cancer.

Figure 97 – River Opening Sign (4/17/2012)

The conclusions presented by the PHA enabled the FOSC to begin coordination of a sequenced opening of the river with state and local health and public safety officials. The first segment opened was from the Perrin Dam in Marshall to Saylors Landing. Because this area was upstream of the confluence between Talmadge Creek and the Kalamazoo River, it had not been significantly affected by the Line 6B discharge. However, this segment was used to establish background conditions. On June 21, 2012 an additional 34 mi of the Kalamazoo River and the entire two mi of Morrow Lake were opened for recreational use (Figure 97). A small portion of the Morrow Lake Delta remained closed as a safety measure for the public and the safety of workers conducting active response activities in that area.

In order to ensure boat operators and workers were ready to share the river with recreational users, comprehensive planning was conducted to evaluate hazards and risks associated with joint use of the river system. The opening of the Kalamazoo River also included media and kiosk documents outlining work areas and safety concerns for the public. Safety boats in communication with response-related boats coordinated with each other to minimize contact with public boaters. However, there were several cases of boat encounters at corners with limited field of sight.

After the initial opening of the river, limited segments were closed if specific work tasks created adverse risk to the public. Response activities in 2013 required limited-duration closures while response actions were performed in specific segments. In the summer of 2013, larger segments of the Kalamazoo River were closed as a result of dredging at the Ceresco Dam and Mill Ponds areas. Approximately six mi of the river were closed until dredging of these areas was completed. This closure was conducted to provide additional safety for the public and workers on the river during active dredging activities. All closures were done in accordance with permitting required by the State of Michigan.

6.2.6. Surface Water Irrigation and Livestock Watering Advisory

On July 27, 2010 MDA issued an advisory on the use of surface water from the Kalamazoo River and other connected waters for irrigation and livestock watering purposes. This precautionary temporary advisory was issued to protect human health and to prevent groundwater contamination.

On August 1, 2010 KHCS issued a ban on the use of water in the Kalamazoo River for irrigation and watering livestock from the Calhoun County line through Kalamazoo County to the Morrow Lake Dam. On August 3, 2010 CCPHD issued a ban on the use of water in the Kalamazoo River for irrigation and watering livestock from the Source Area to the Calhoun County line.

The MDA advisory was lifted on August 7, 2010; however, the CCPHD and KHCS bans remained in effect until the river was opened for recreational usage in 2012.

6.2.7. Drinking Water Evaluation

Beginning on July 27, 2010, CCPHD, KHCS, state and federal government partners, and Enbridge conducted a systematic evaluation of private drinking wells located along the impacted stretch of the Kalamazoo River and Talmadge Creek at their high water levels. The investigation included a review of well construction records, movement of groundwater, and determination of areas of greatest risk.

On July 29, 2010 CCPHD issued a bottled water advisory for residents with private wells living within 200 ft of the Kalamazoo River and Talmadge Creek at their high water levels to the Calhoun/Kalamazoo County line. Although no contamination was found, Enbridge, under the direction of CCPHD and KHCS, provided bottled water to these residents for drinking and cooking as a precaution.

Enbridge initially sampled private wells as requests were received from residents. At the request of the local public health departments, EPA formalized the drinking water program requirements as part of its September 23, 2010 Supplemental Order. The Order required Enbridge to sample groundwater from public and private drinking water wells located within 200 ft of the high water line for affected waterways, perform a hydrogeological assessment of the groundwater near the Kalamazoo River, and provide preliminary information for establishing a long-term drinking water evaluation and/or groundwater monitoring program.

Wells within 200 ft of the 100-year flood plain associated with the Kalamazoo River, delineated floodplains of the Kalamazoo River, or areas of documented contamination related to the discharge were eligible for the sampling program. Over 500 individual properties were identified as potentially eligible; however, not all property owners granted permission for sampling to occur. Additionally, some properties were located within the defined zone, but the wells were not within the zone. In total, approximately 155 private drinking water wells were entered into the sampling program. MDEQ and the local health agencies took the lead on implementation and coordination of this program. These wells were initially sampled twice-monthly, and the sampling frequency lessened over the life of the project as no Line 6b spill-related contaminants were observed in sample analysis. The program is currently suspended pending further evaluation from MDEQ and the local health agencies.

A drinking water committee was established and included representatives from EPA, MDCH, CCPHD, KHCS, MDNRE, and Enbridge. Sampling results were presented to the drinking water committee on a weekly basis. On October 31, 2010 the results of the hydrogeological assessment, discussed in Section 6.1.9, were presented to the drinking water committee. The private well sample results demonstrated that residents would not be exposed to oil-related chemicals by drinking their well water. Based on the results of the hydrogeological assessment and the private well samples, CCPHD and KHCS formally lifted the bottled water advisory on November 8, 2010.

After the bottled water advisory was lifted, MDEQ required Enbridge to continue the sampling program to monitor private wells at a reduced frequency. Samples were analyzed for both oil-related and non-oil related chemicals to ensure that drinking water remained unaffected by Line 6B oil remaining in the system. Oil-related organic chemicals were not detected above health-based screening criteria in any of the private well samples. Three oil-related inorganic chemicals, nickel, vanadium, and iron, were detected above health-based screening criteria in the private well samples. Based on the frequency of detection, MDEQ, in consultation with CCPHD and KHCS, determined that the detections of oil-related inorganic chemicals did not require corrective actions such as well replacement or installation of filtration systems. Additionally, iron and nickel were previously detected in area wells and are naturally occurring in the area. This sampling program is suspended pending further review, as stated above.

In addition to the private well sampling program, MDEQ required Enbridge to sample groundwater near the City of Kalamazoo Well Field #39 and the Village of Augusta Municipal Wells. Five monitoring wells were sampled at each location. Oil-related organic chemicals were not detected above health-based screening criteria in any of the municipal well field samples. Iron was detected above health-based screening criteria; however, iron is naturally occurring in the area. This sampling program is suspended pending further review, as stated above.

6.2.8. Fish Consumption Advisory

On July 27, 2010 MDCH issued a public advisory to not consume fish obtained between Talmadge Creek near the Source Area and the west end of Morrow Lake. MDNRE collected fish samples in 2010 after the discharge. The MDCH Analytical Laboratory analyzed the edible portion samples for oil-related and non-oil related chemicals. These sample results did not show oil effects. However, this specific fish consumption advisory remained in effect until two years of sampling data were obtained. Additional fish samples were collected and analyzed in 2011. Based on analytical results from both years, MDCH lifted the fish consumption advisory related to the discharge on June 28, 2012; however, existing pre-discharge fish consumption advisories related to historic contaminants in the Kalamazoo River remained in effect.

6.2.9. Groundwater Assessment

Pursuant to the September 23, 2010 Supplemental Order, the FOSC required Enbridge to perform a hydrogeological assessment of the groundwater near the affected portion of the Kalamazoo River. Because the private well sampling program, discussed in Section 6.2.7, was dependent on voluntary residential participation, the hydrogeological assessment was used to fill in the data gaps from that study.

The primary objective of the hydrogeological assessment was to determine whether various portions of the Kalamazoo River were gaining (groundwater flow towards the river) or losing (groundwater flow away from the river), particularly in areas with known surface water impacts from the discharge located near private drinking water or municipal wells. This information was used to determine if drinking water aquifers along the Kalamazoo River were affected or had the potential to be affected by oily surface water.

Eight study locations were selected that were representative of the different hydrogeological conditions of the Kalamazoo River. These target areas included the confluence of Talmadge Creek with the Kalamazoo River, the Ceresco Dam impoundment area, the Mill Ponds impoundment area, the Morrow Dam impoundment area, and four areas between MP 22.50 and MP 36.25. A minimum of three monitoring wells (2 shallow and 1 deep) were installed at each location. The monitoring wells were tested as follows:

- hydraulic gradient determinations via collection of groundwater elevation data and Kalamazoo River elevation data on three different dates,
- in-situ hydraulic conductivity testing at select wells within each target area, and
- sampling and chemical analysis of each of the monitoring wells.

The hydrogeological assessment also included an evaluation of production and municipal wells located near the target areas to determine if pumping from these wells could influence groundwater flow or direction.

Results of the hydrogeological assessment indicated that the Kalamazoo River was primarily a gaining river, where groundwater flows toward and discharges into the river. Exceptions included the Ceresco Dam impoundment, where the results indicated that the river is a losing river in which groundwater flows away from the river, and the Mill Ponds Impoundment area, where data conflicted between whether the river was gaining or losing. Analyses of samples collected from the monitoring wells indicated that oil constituents in the surface water had not affected the adjacent groundwater.

Enbridge continued to implement a long-term monitoring program at the eight target areas under an agreement with the MDEQ. As of March 2014, this monitoring program is suspended pending further review, as stated above.

6.2.10. Public Health Communications

Communications regarding public health were issued during the response and included press releases and advisories, no contact orders, and medical information sheets to residents and physicians. In addition, a database of residents within 200 ft of the affected area, from the Source Area to Morrow Lake Dam, was maintained. These residents were informed of basic information on how to deal with the discharge, contact phone numbers, and shelter information. Community meetings were held periodically to inform the public on the progress of the response and to address citizen concerns.

Timely communication from public health agencies was key during the initial weeks of the response. In the first few weeks of the discharge, cognizant agencies established specific websites related to the discharge and/or added discharge-specific information to existing sites.

Throughout the response, EPA established site information repositories at the Marshall District Library in Marshall, the Helen Warner Library in Battle Creek, and the Willard Public Library in Battle Creek. EPA also published the following fact sheets about the site:

- Oil Spill: How Can I Help Wildlife or Volunteer? – August 12, 2010,
- Oil Spill: How is Air Quality Affected? – August 19, 2010,
- Oil Spill: Water Issues – August 19, 2010,
- Oil Spill: Changes Seen As Cleanup Response Evolves – September 2010,
- Oil Spill: Agencies Plan Long-Term Activities – October 2010, and
- Cleanup Progress – Plans for Spring Work – April 2011. This fact sheet was produced in English and Spanish and was printed in its entirety in English in the *Advisor Chronicle* and the Battle Creek *Shopper News*. Instructions were provided on how to request it in Spanish.

In August 2010, CCPHD and KHCS sent letters to health care providers requesting information on patients exhibiting symptoms of oil exposure associated with the discharge. During August 2010 the MDCH Field Epidemiology Team formed a surveillance program, including a call center and a field team, in response to significant citizen complaints about health symptoms and odor from the oil. The team completed special door-to-door symptom surveys in two areas: Baker Estates and the Playcare Learning Center. The surveillance team targeted door-to-door symptom surveys for three additional areas: Squaw Creek, the former evacuation area, and Ceresco Dam.

In November 2010, MDCH issued a report titled "Acute Effects of the Enbridge Oil Spill." The report provided the results of a multifaceted public health surveillance system implemented by state and local public health agencies. The surveillance system received 147 health care provider reports on 145 patients, identified 320 individuals with adverse health effects from four community surveys along the affected waterways, identified one worksite symptomatic employee, and tracked 41 calls that were placed to the poison center. Headache, nausea, and respiratory effects were the predominant symptoms reported by exposed individuals. The report concluded that these symptoms were consistent with the published literature regarding potential health effects associated with crude oil exposure.

MDCH (in conjunction with US Health and Human Services and ATSDR) issued four separate PHAs entitled:

- "*Evaluation of crude oil release to Talmadge Creek and Kalamazoo River on residential drinking water wells in nearby communities*" (MDCH, 2013),
- "*Evaluation of Air Contamination*" (Public Comment Release, MDCH, 2014),
- "*Evaluation of people's risk for health effects from contact with the submerged oil in the sediment of the Kalamazoo River*" (MDCH, 2012), and
- "*Evaluation of Kalamazoo River surface water and fish after a crude oil release*" (MDCH, 2013).

These reports were provided to the public via media releases, posted to the MDCH website, and placed at local repositories for public viewing.

CCPHD posted Air Quality and Volunteer Fact Sheets on the Calhoun County Website and sent out a media advisory regarding Enbridge to its local media contacts. CCPHD reported that they received inquiries from the media regarding evacuation protocols, as well as effects on drinking water wells.

KHCS posted information about the Line 6B discharge on their website and also included links to the EPA website.

On December 22, 2011 the CCPHD health officer issued an update describing actions taken by local health agencies to protect public health. He reported: *"Exposures, particularly by inhalation, may have been significant in the days immediately following the oil spill when chemical contaminant levels were high. However, data gathered in the fall of 2010 through the current date indicate that contaminants have returned to levels that are unlikely to cause human health effects. Sampling prompted by initial concerns about impacts to private wells has demonstrated that people have not been exposed to oil-related chemicals by drinking their well water."*

Web and media advisories continue.

6.3. Worker Safety

Consistent with the NCP, worker health and safety were primary concerns for the FOSC. OSHA and MIOSHA requirements for safety and training provided the minimum safety requirements for the response. EPA used its pre-established Emergency Responder Health and Safety Manual, which covers hazards encountered on emergency response and time-critical removal actions. EPA START contractors also had response HASPs that were established at the beginning of the response. As part of the Administrative Order issued by the FOSC, Enbridge was required to submit a HASP for response activities to the FOSC.

The duration of this response resulted in additional hazards not necessarily encountered during a typical response lasting weeks or even months. The hazards and risks associated with flooding, heat, chemical exposure, drowning, fatigue, noise, poisonous plants, biting and stinging insects, animal contact and recovery, traffic congestion, heavy equipment use, and aviation and boating operations, as well as numerous other hazards, made work complex. Workers were presented with potential contact to oil through the recovery process. In addition, as is typical with emergency response work, workers faced the psychological and social effects of stress, anxiety, and tension caused by the immediacy of responding away from customary and routine work tasks and personal life.

Medical plans were instituted within the first days of the response. Hospitals in three separate cities were identified based on the size and distances of the response area. Additionally, Emergency Medical Technicians (EMT) were part of the response team during the initial phases of the response.

The amount of field personnel and tasks performed during the response varied depending on response objectives and seasons. However, management, including technical support, and administrative activities were maintained at a constant level to ensure project progression and continuity.

During the summer and early fall of 2010, operations were conducted 24 hours/day for seven days/week. In October 2010, the number of workers decreased to approximately 1,400 personnel, and the UC emphasis was realigned to match changing recovery priorities. The combined number of personnel on site in 2011 ranged from approximately 100 to 900 personnel. The combined number of personnel on site in 2012 ranged from a low of 30 personnel to a high of approximately 300, with the elevated number of personnel occurring during the winter and spring months. The combined number of personnel on site averaged 199 in 2013, and 139 in 2014.

6.3.1. Aviation Safety

Within the first days of the response, helicopter support was established by both the MSP and Enbridge for situational awareness and photographic documentation. Early in the response, the FOSC recognized the importance of continued aerial surveillance of the discharge and authorized the Finance Section to establish an on-call contract with a helicopter vendor. The selected vendor was verified to meet Federal Aviation Administration (FAA) requirements for equipment and pilots. During the initial phase of the response, USCG provided an Air Operations Assistant SO to support EPA.

Initially, EPA and Enbridge conducted separate, and sometimes multiple, daily aerial overflights for oversight and photographic documentation. On August 23, 2010 Enbridge and EPA Situation Unit (START contractors) began conducting combined overflights, funded by Enbridge, using the same helicopter vendor that EPA selected. EPA's on-call contract remained in place for times when EPA employees or contractors required specific information.

In addition to situational awareness and photographic documentation, Enbridge used helicopters to airlift debris bags and drop equipment into several remote sites. During these activities, safety personnel restricted work activities adjacent to air operations.

All helicopter use was in compliance with OSHA 29 CFR 1910.183, relevant FAA requirements, and Enbridge's HASP section outlining air safety.

6.3.2. Boating and River Safety

During the initial phase of the response, over 200 boats were used, including air boats to access flooded overbank areas and flat bottom outboard prop boats. The majority of boat use occurred in Division C. The large quantity of boats created congestion at launch sites, as vehicles launched and recovered boats. Overnight security was implemented at docks in order to leave boats in place until work was completed.

The use of air boats continued until December 2011, when decreasing water levels minimized the need to access flooded overbank areas by boat. While air boats still functioned in these conditions, Enbridge discontinued their use based on the combination of noise associated with air boat traffic and the inherent lack of control during low speed maneuvers. Enbridge began employing only flat bottom or low-draft boats with outboard motors and jet drives. The jet drive allowed for increased maneuverability, the ability to function in shallow water, and decreased noise as compared to air boat traffic.

6.3.3. Land Operations Safety

Complex land operations were involved in phases of the response, each with specific hazards and risks. These operations included road blockages, heavy equipment operation, preparation of boat launches and docks, construction and removal of mat roads, and construction of temporary work sites and access roads.

Dredging at the Ceresco Impoundment and other sites, especially during 2013, were major construction events. Lay down and active work areas were designed and constructed. Truck traffic in and out of these work areas created potential concerns for impact to the public. Work areas were operated in accordance with MDOT requirements. Traffic control personnel and traffic control plans were used to minimize impact to the public impact.

Excavation of affected soil from the Source Area, Talmadge Creek, and the Kalamazoo River shoreline, overbank, and islands required planning and implementation to address unique hazards. Additional hazards and risks were revealed by the need to get equipment into and out of some remote areas. This necessitated the design and construction of temporary roads and temporary bridges. HASP task implementation, with daily work permits and training, was conducted to ensure risks were minimized.

6.3.4. Worker Air Monitoring

During the initial response activities, air monitoring and sampling were performed to assess and evaluate air quality for worker safety. Air samples were collected using sorbent tubes and analyzed for aromatic hydrocarbons using National Institute for Occupational Safety and Health (NIOSH) method 1500/1501. MIOSHA compiled occupational exposure standards and guidelines established by OSHA, MIOSHA, and the American Conference of Governmental Industrial Hygienists (ACGIH). Worker air monitoring and sampling data was compared to the occupational exposure standards and guidelines as selected by public health department representatives.

Beginning on July 28, 2010, organic vapor passive air monitoring badges were provided to personnel working on or around waterways potentially affected by the discharge. This included individuals performing air monitoring and sampling, boom and cleanup operations, vegetation removal, and working in Frac Tank City. Personnel badges were worn for a shift and sent for laboratory analysis for VOCs or BTEX (benzene, toluene, ethylbenzene and xylene) using NIOSH method 1500/1501. From July 28, 2010 through November 27, 2010, a total of 1,738 badges were collected and analyzed.

Work area air samples were collected from September 30 through October 31, 2010 during dredging operations conducted at the Ceresco Impoundment. In total, 233 12-hour samples were collected for metals and airborne dust. All concentrations were below MIOSHA action levels.

In accordance with the approved 2011 Air Monitoring and Sampling Addendum (Enbridge, 2011a), Enbridge performed air monitoring and sampling in work areas to assess worker inhalation exposure to contaminants of concern. Air monitoring and sampling were implemented during specific intrusive cleanup activities in June and July 2011, including boom operations, hand shoveling, machine excavation, sediment agitation and oil recovery, and poling. Monitoring was conducted for VOCs using MultiRAE PIDs at representative work locations. Air sampling was conducted using passive dosimeter badges, with 262 passive dosimeter badges provided to workers performing various cleanup activities. All 262 samples were submitted for laboratory analysis of VOC contaminants of concern.

From January through September 2012, air monitoring was implemented to assess worker inhalation exposure to contaminants of concern during specific intrusive cleanup activities, including boom deployment and maintenance, debris recovery, overbank excavation, and submerged oil and sediment poling. MultiRAE PIDs were deployed to monitor VOCs, CO, and H_2S, and UltraRAEs were deployed to monitor benzene.

The combined number of personnel on site in 2013 ranged from a low of 50 personnel to a high of approximately 500. Winter work included tasks associated with containment, O&M, and recovery, except that overbank excavation and submerged oil agitation were not performed. Dredging was performed during the summer and fall of 2013, thereby creating a demand for additional workers and increasing hazards and risk associated with heavy construction-type work.

From July through December 2013, air monitoring was implemented to assess worker inhalation exposure to contaminants of concern during specific dredging related cleanup activities. MultiRAE PIDs were deployed to monitor VOCs, CO, and H_2S, and UltraRAEs were deployed to monitor benzene at representative work locations.

Over 900,000 real-time air monitoring measurements were collected for VOCs, CO, and H_2S at work locations from July through December 2013. No UltraRAE monitoring was performed because the VOC measurements did not exceed the trigger concentrations requiring benzene-specific monitoring.

A limited number of organic vapor passive air monitoring badges were provided to personnel working near dredging activities at the Ceresco Impoundment. This included individuals performing sheen sweeping activities, dredge operations, and pug mill operations. Personnel badges were worn for a shift and sent for laboratory analysis for VOCs and BTEX (benzene, toluene, ethylbenzene and xylene) using NIOSH method 1500/1501. A total of 26 badges were analyzed.

Due to potential dust and silica exposures, Enbridge also collected a limited number of worker air samples during pug mill operations associated with the dredging operations at the Ceresco Impoundment. 12 samples were collected for analysis of metals and total dust, and 11 samples were collected during full shift operations for analysis of silica and respirable dust. Results indicated no detections of silica and no exceedances of MIOSHA permissible exposure limits for dust or ACGIH threshold limit values for metals.

6.3.5. Transportation Safety

Trucking and waste transportation were performed throughout the response. Vehicle operators were provided expectations of their safety responsibilities. Spotters were utilized when practical to limit hazards associated with backing and blind spots. Cell phone use while operating was strictly prohibited. Drug testing was mandatory following an incident, regardless of fault.

During dredging activities, scaffolding was erected to assist working in lining truck beds, and liner restraints were fabricated that allowed workers to clear the sides of truck beds after they were filled without climbing the sides.

Traffic control plans were prepared for active sites, including parking restrictions and traffic flow paths for fixed sites. For sites adjacent to active roads, the plans were augmented with trained flaggers to provide effective and safe traffic flow.

Certain areas during the initial response phase required road closures and lane restrictions, flaggers, and signage. Coordination with local law enforcement and compliance with MDOT requirements was enforced.

6.3.6. Water-Related Safety

Flooding conditions during the initial discharge, as well as during the spring of 2011, created multiple hazards for workers. High-water conditions required workers to access flooded lowland areas by both boat and on foot.

Water levels became extremely low in 2012, revealing rocks and other obstructions within the river system. These hazards precipitated the need for consistency in boat operators that had intimate knowledge of the navigable waterways. Water hazards were marked and certain areas became limited to wading or walking. Boat operator training was conducted to provide a unified approach to hazard identification and avoidance, as well as providing requirements for safety equipment and communications.

Two low-head dams within the affected area of the river system created concerns for access by means of boats. Restriction of routine access to a minimum of 100 ft, combined with cable catch assemblies during necessary closer approach tasks, was utilized to provide protection.

Installation of floating bridges or other temporary bridges for equipment access to remote areas and islands created potential safety concerns. These concerns included the use of heavy equipment in or above waterways and the associated construction associated with bridge fabrication and use over an active river system.

6.3.7. Temperature

Weather conditions encountered included rain, snow, ice, fog, thunderstorms, and tornadoes. While work continued when practical during these conditions, work techniques and safety requirements were adapted to ensure safe conditions.

Early in the response until mid-2011, weather information was coordinated with the National

Weather Service (NWS), who stationed personnel at the project site. After that time, a stand-alone weather information system was instituted and utilized.

Extremes in temperature and weather were additional hazards not typically faced during many response events. Work during the Line 6B response was conducted in temperatures ranging from sub-freezing to over 100 °F.

Rest stations with hydration fluids and temperature controls were constructed where possible. Some of the residential homes purchased by Enbridge during the response were made available as tornado shelters.

Heat stress was a recognized hazard throughout the response; however, it was most apparent during the initial phase of the response (approximately 10% of total health and safety incidents) due to ambient temperatures and PPE requirements for those workers actively recovering oil. Heat stress protocols were discussed with and implemented by Enbridge, which required enforced work/rest schedule cycles to ensure the avoidance of heat stress injury or illness. Cooling tent structures with fans, cool water, and nourishment were provided in many locations. Heat stress protocols were assertively enforced in locations. During 2011, heat stress-related cases dropped to approximately 5% of total cases, and in both 2012 and 2013, less than 1% of total cases reported involved heat stress. This trend of limited responses to heat stress continued in 2014.

6.3.8. Communication

The response organization used MSP 800 MHz digital radios for communications during the initial phase of the response. During the spring of 2011, communications for response personnel was accomplished via a push-to-talk system. This system was subsequently changed to an automated phone system utilizing conventional mobile phones, which was successful in providing real-time information related to storm systems and/or hazards (e.g., traffic accidents) that could affect work operations or worker safety.

Work permits and safety briefings were performed daily during IAP operations briefings or during shift changes prior to work. Events outside of the permit, including change of task or time, required reauthorization and approval of a modified work permit.

During 2011 and 2012, the weekly IAP briefing and daily staff briefings were conducted in the morning, prior to work, at a central location, typically the ICP. Enbridge conducted these briefings, with EPA and MDEQ participation and assistance when appropriate. In addition to the staff briefings, on-site tailgate sessions specific to the work tasks were conducted utilizing a work permit process. These briefings continued into 2013 and 2014.

6.3.9. Personal Protective Equipment

The potential for health effects from inhalation or contact with the discharged diluted heavy crude oil and other work-related chemicals was a focus during the initial phase of the discharge. As the response progressed, the primary exposure concerns for benzene and other volatile constituents of the oil were replaced by weathered oil and chemicals brought to the site to complete work efforts, including fuels, lubricants, and polymers. Whereas most response efforts deal with a limited number of chemicals or contaminants, the on-going efforts for this response required the FOSC to continually evaluate the potential for exposure.

Figure 98 – Personal Protective Equipment during Boom Decontamination (10/5/2010)

Safety personnel monitored worker safety and health throughout phases of the response to ensure that appropriate protection was used based upon hazard and risk. OSHA Levels B, C, and D were used during the response (Figure 98). The use of Levels B and C was limited to specific tasks or locations that dictated the need for higher levels of respiratory protection, as discussed in Section 5.9.3. This strategy prevented adverse effects from the overprotection of workers.

On July 29, 2010 federal and state OSHA representatives who were visiting the site at the request of the FOSC inspected work areas. Deficiencies in the use of personal protective equipment, specifically respiratory protection, were observed. Two days later, EPA and OSHA representatives investigated reports of elevated benzene concentrations in the Division A work area and concluded that existing controls were adequate to address OSHA guidelines for personal protective equipment.

Breathable protective apparel was preferred when possible. However, fire resistant clothing was required throughout the entire Source Area during the initial days of the response. Additionally, Tyvek® or equivalent materials were used when dermal contact was a safety concern. This necessitated stringent monitoring for heat stress and/or fatigue. The SO utilized the "Public Health Assessment - Evaluation of people's risk for health effects from contact with the submerged oil in the sediment of the Kalamazoo River" (MDCH/ASTDR, 2011) as a review tool to evaluate the risks and benefits of continuing worker skin protection. The PHA evaluated both the short-term and long-term effects from exposure to the oil by the public. The PHA concluded that repeated exposure to the oil by the public would not result in long-term health effects.

Therefore, it was appropriate to use this information in evaluating effects on workers since their exposure to the oil was not expected to be long term. Following review, the requirement for the use of Tyvek® was discontinued for the majority of field tasks in July 2011, which greatly reduced the risks of heat stress and limited mobility.

In addition to monitoring for inhalation and dermal contact hazards, safety personnel controlled noise exposure through the use of hearing protection. Personnel were required to utilize hearing protection on airboats while in motion. Hearing protection was also used for personnel working around heavy equipment, as necessary.

6.3.10. Other Considerations

Restroom and worker hygiene issues were a challenge at the beginning of the response because of remote and difficult to access work sites. As a result, portable restrooms were utilized, and work practices required that restroom and sanitation facilities be available within 10 minutes travel of work areas.

During summer months, fire concerns due to dry conditions had to be kept at the forefront of risk management. Workers were advised to be aware of fire producing conditions. This included avoiding the use of fire or spark-producing tools and not parking vehicles in dry grass areas to minimize the potential of starting fires.

A worker policy and program for blood-borne pathogens were enacted because needles were found in the river and adjacent shorelines. This procedure also included maintaining sharps disposal containers on safety boats.

6.3.11. Wildlife Personnel Safety Training

Some USFWS personnel and contractors already had 24-hour or 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) certification prior to arrival at the Line 6B response. However, the Wildlife Branch provided a site-specific training program, entitled "4-Hour Safety Awareness Training for Oil Spill Workers", for wildlife response personnel who did not have HAZWOPER certification. The training was specific to the Line 6B Spill response and was performed primarily to introduce wildlife personnel to oil spill operations.

Wildlife responders and care workers also received additional task-specific training by their supervisors as necessary, but most were selected specifically for their expertise in working with wildlife. The Wildlife Branch developed a branch-specific HASP to augment the Line 6B response HASP.

6.3.12. Unique Situations Encountered

In November 2010, human remains were discovered in an affected portion of the Kalamazoo River in Battle Creek. As a result, workers were provided instructions and reminded of the need for contacting local authorities if similar situations were encountered. Workers were also encouraged to communicate with their employers if mental concerns related to locating the human remains became an issue.

A sewage release from the Battle Creek Wastewater Treatment Plant occurred on May 20, 2011. Response workers were removed from those areas of the river that were affected by the sewage release, which extended from the wastewater plant through Morrow Lake. After water samples were analyzed for bacteria and results evaluated by the CCPHD, work resumed in this stretch of the Kalamazoo River on May 23, 2011.

A 50-year flood and storm event caused flooding and downed trees in work areas on May 29, 2011. Roads in many areas were not accessible due to downed power lines and trees. Trees were toppled into areas of the Kalamazoo River, creating additional on-water access hazards and hanging limbs along areas of the river system. All work was stopped until downed trees and debris within the river could be cleared and hanging limbs or other hazards identified and mapped. As a result of this event, known river hazards were mapped and marked to ensure safety for the remainder of the response.

Sediment dredging created multiple hazards associated with on and off water construction. Hazards included the simultaneous use of multiple dredge machines, numerous support boats in close proximity, miles of pressurized pipe, use of a pug mill for sediment solidification, and a GAC water treatment system. The dredge pad used to collect and manage recovered sediment also presented typical construction hazards associated with heavy equipment use and construction activities.

Additional concerns (e.g., steps, ergonomics, fire safety, and electrical safety) typical of office environments were also present and managed.

6.4. FOSC Commentary on the Effectiveness of the Safety Program

Beginning on July 26, 2010, EPA determined that the protection of public health and response workers was the paramount response objective. This determination was documented in every IAP developed for every operational period up to the completion of the response in October 2014.

The early and immediate mobilization to the response by public health experts from state and federal agencies (MDCH and ATSDR) at the request of the FOSC ensured that county health departments and public safety agencies were properly supported and integrated into all aspects of the evolving UC/ICS. This was critical in ensuring that the public safety objective established by the FOSC and UC was properly implemented and received the highest priority. The sustained participation of CCPHD, KHCS, and MDCH as members of the UC through 2011 and eventually again as strong participants in the succeeding MAC and Stakeholder Group helped to ensure systematic attentiveness to all aspects of public health and safety discussed above.

Public health and safety ramifications were routinely discussed and evaluated in the context of all major response operations initiatives for the duration of the response. Similarly, worker safety considerations were integrated with routine hazard evaluation.

As the complete magnitude and geographic scope of the spill event were coming into focus, mobilizations of resources accelerated while response strategies, operations tactics, and occupational safety and exposure hazard analyses were still being developed. This fact and the necessary participation of scores of government agency and RP contractor groups combined to present immense occupational safety challenges. These challenges were exacerbated by extreme and sometimes dangerous field conditions. In short, the challenge became one of building a response organization comprised of many diverse groups that would eventually be over 2,000 persons strong and simultaneously building a unified, governing safety program as response activities and operations were proceeding.

To underscore EPA's high priority of worker safety, the FOSC requested that OSHA and MIOSHA conduct a coordinated evaluation of the occupational exposure and site safety practices during the first two weeks of the response. They then worked with safety personnel from EPA and Enbridge to develop and implement safety programs, policies, and plans. The federal and state safety agencies agreed to do this in a consultative mode as opposed to an enforcement mode for a short period of time in the spirit of building a strong safety culture during an unprecedented event. As was the case for public health and safety, this early strategy to design and build culture around a priority overall incident objective paid great dividends going forward. While it is certainly the case that the response's overall highly effective safety program resulted from routine, day-in/day-out emphasis, the culture and command objectives that enabled it were established early and supported with the best available professional and regulatory expertise available.

These early recognitions and resultant practice of public health and safety and worker safety as ultimate driving objectives for the entire response organization established a tone and culture that carried through the duration of the response and which resulted in enduring and successful achievement of that objective.

To emphasize the importance of this safety objective throughout the response organization down to the field worker level, IAP briefouts became a major focus during the life of the response. At each of these, the key leadership positions would brief response staff down to the division/group supervisor level. Although the Safety Officer always presented a safety update, many times the Incident Commanders (including the FOSC) would reemphasize safety by providing a relevant story of a lesson learned or would focus on a key operational concern as it related to safety of site personnel or the community.

In terms of more specific safety lessons learned, emphasis should be placed on the concern for evaluating and protecting against public health and occupational exposures associated with air concentrations of volatilized spilled oil. This is almost always true for large oil spills, and this case was no different. To that end, the best air monitoring equipment and personnel should be mobilized as soon as possible. Following the oil spill, responders did not have the capability to measure benzene air concentrations below 50 or 60 ppb via real-time monitoring. This resulted in very real challenges for public health decision making until an EPA mobile laboratory with the ability to perform real-time measurements at lower levels was mobilized. The concurrent BP Gulf Oil Spill response was using all EPA Trace Atmospheric Gas Analyzer (TAGA) resources. For future responses, earlier deployment of that capability would be beneficial and highly recommended for assurance of public health and occupational safety. Eventually a piecemeal system was brought to the site to support the FOSC instead of the TAGA, and a TAGA-equivalent system was offered for use by our Canadian counterparts at Environment Canada.

Mechanisms should be pursued through the USCG National Pollution Funds Center to allow for mobilization and payment for the use of these types of assets when appropriate EPA assets are unavailable during a major oil spill response. The mechanism to mobilize these assets from Canada would be covered in this type of incident by the CANUSCENT Annex to the Canada-United States Joint Inland Pollution Contingency Plan, but that annex and the larger plan do not provide a mechanism to reimburse Canada for the use of these assets requested by EPA or USCG during an incident.

7. Planning

The Planning Section was responsible for the collection, evaluation, and communication of information to support field operations within the ICS structure. Gathering accurate and timely information for the FOSC and Operations Section was crucial not only during the initial phase of the incident when response and staffing needs were dynamic, but also throughout the extended portion of the response where field operations and related functions were weather and season dependent.

7.1. Information Collection

Field observers (FOBs) were utilized throughout the response. Information obtained during the response was documented and then compiled into draft situation reports (SITREPs), which were edited and used by the FOSC to inform other members of the UC, as well as cooperating and assisting agencies, of response status and achievement metrics.

ICS Form 214 - Unit Logs were used to document activities throughout the response. Field staff prepared 214s to report activities, observations, and challenges encountered to the ICS chain of command and to aid in situational awareness reporting. The reporting included 214 forms completed by individuals, as well as team (e.g., groups, branches, divisions) summary reports. These reports included narrative and visual documentation (e.g., photographs) for various ICS positions, including field observers and other Situation Unit personnel reporting from land-based operations, boating operations, and air operations (i.e., helicopter reconnaissance).

7.1.1. Information Requests to Enbridge

As the response grew in complexity and magnitude, it became necessary to establish a written process for documenting and tracking information requests made by EPA to Enbridge. As a result, requests for information from the various EPA ICS sections were channeled through the EPA Planning Section, and the EPA Planning Section made written information requests to Enbridge. The requests included the information required, format for the response (e.g., text document, spreadsheet, GIS database, etc.), and the timeframe for complying with the requests. This optimized tracking, control, consolidation, and prioritization of information requests.

7.2. Information Dissemination

Information gathered during the response was disseminated in a variety of methods depending on the needs of the target audience. The primary methods of information dissemination are presented below.

7.2.1. Planning Cycle, IAPs, and SITREPs

The IAP was an organizational tool used to communicate requirements for execution of the day-to-day operations. The IAP contained the incident objectives and operational emphasis established by the UC and the FOSC. The IAP was issued at frequencies dictated by the ongoing operations. As such, IAPs were produced daily at the beginning of the response when activities were in a constant state of flux. As the response situation stabilized, IAPs were issued at frequencies from every three days to twice-monthly.

EPA produced the IAPs during the initial phases of the response while Enbridge was establishing its ICS structure. EPA transferred responsibility of IAP preparation, under EPA direction, to Enbridge when its Planning Section became more fully functional. IAPs were distributed during operations briefings and were available to response personnel.

Similar to the IAPs, SITREP preparation tracked with the operational period. The SITREP provided information to inform a broad audience, including: on-site and off-site stakeholders; federal, state, and local agencies; and technical and non-technical persons. The SITREP provided information to summarize the progress of the response and included operational metrics, as well as narrative descriptions of activities performed and challenges encountered.

7.2.2. Situational Awareness Updates

Timely and accurate situation updates were a critical communication tool for informing response personnel on the status of the response. These updates were incorporated into most meeting agendas. The updates included photographic documentation collected from helicopter reconnaissance, as well as land and boat observations. The updates usually progressed from upstream (i.e., the pipeline rupture location) to downstream, terminating at the Morrow Lake Dam. Situation displays were also maintained at the ICP, first outside the EPA Planning Section office at the Walters Elementary School and then later in the warehouse at the Pratt Road ICP.

7.2.3. EPA Website, Fact Sheets, and Presentations

When directed by the FOSC, the EPA Planning Section provided the EPA Region 5 Director of the Office of External Communications information and documents for placement on the EPA Region 5 website. The *EPA's Response to the Enbridge Oil Spill* website contains key EPA documents, SITREPs, select State of Michigan documents, and Enbridge response documents.

The Public Information Officer (PIO) prepared EPA fact sheets, which were then made available to stakeholders. Planning Section personnel supported the FOSC in preparation of presentations for public meetings and response open houses and by providing statistics, graphics, metrics, photographs, and videos as requested.

7.3. Meetings

A summary of the regularly held meetings is presented below. Most were conducted during each operational period.

Objectives Meetings: The UC ICs reviewed and established the incident objectives and command emphasis for each operational period.

Command and General Staff Meeting: The Command and General (C&G) staff meetings were held so the Section Leaders (e.g., Operations, Planning, Logistics, etc.) could represent the interests of their respective sections and provide consolidated recommendations to the FOSC.

Pre-Tactics Meetings: The purpose of this meeting was to review the incident objectives/emphasis and develop a strategy for approaching/staffing/resourcing operations, logistics, and safety for a given operational period.

Tactics Meetings: Tactics meetings were held to develop strategies and determine resources needed to achieve the incident objectives.

Planning Meetings: The proposed IAP for the next operational period was presented during planning meetings. Approval/support for the IAP was obtained from members of the C&G Staff.

IAP Operations Briefings: Operations briefings were conducted at the beginning of each operational period to present the IAP to response personnel. The Situation Unit Leader provided a situation update during this meeting. When appropriate, these briefings were conducted by field team leaders at various operations stations throughout the response area.

Special Purpose Meetings: When requested by the FOSC, special purpose meetings were held outside of the normal planning cycle to address specific topics.

Multi-Agency Coordination Group Meetings: On November 8, 2010 the response organization changed from the ICS to a non-ICS format, at which time the MAC Group was formed. The MAC Group was comprised of former UC membership. The MAC Group meetings were used to keep stakeholders informed of project activities and to provide a forum for the MAC members to make recommendations to the FOSC. The MAC Group met weekly between November 2010 and May 2013, although project governance returned to ICS format on February 28, 2011.

Stakeholder Group Meetings: On May 1, 2013 EPA and MDEQ convened a group of stakeholders to discuss how to continue effective communication, sharing of project progress, and continue eliciting feedback about the needs of the local communities. The group represented a combination of MAC and the DEQ Citizen Advisory Group members.

Consolidated ICS Meetings: In November 2012, EPA approved the implementation of a scaled ICS organizational concept. As a result, a consolidated ICS meeting was held regularly. This meeting combined the purpose and components of the ICS C&G staff meeting and planning meeting, followed by approval of the IAP and setting the upcoming objectives. It also included a comprehensive situation update. The first consolidated ICS meeting was held on November 14, 2012.

7.4. Plan Preparation/Review

At the time of the discharge, Enbridge did not have adequate and specific enough plans for a response of this magnitude and complexity. Enbridge submitted plans to EPA, which, due to a lack of appropriate content, were disapproved by EPA. As a result, EPA drafted interim plans to guide the response while Enbridge continued to develop appropriate plans.

EPA Planning Section personnel received Enbridge plans and distributed them to EPA and other reviewers, including MDEQ, as directed by the FOSC. Recommended comments and suggestions were made to the FOSC, and the FOSC approved the plans or required further revision by Enbridge.

In addition to plans required by EPA's 311(c) Administrative Order, Enbridge also provided plans to MDEQ pursuant to the State of Michigan's orders. When requested by MDEQ, EPA reviewed plans that Enbridge prepared for MDEQ-lead portions of the response and offered comments to MDEQ. This process enabled consistency between response activities performed pursuant to state and federal requirements.

7.5. Environmental Unit

The purpose of the Environmental Unit within the Planning Section was to provide scientific support to the FOSC throughout the response.

7.5.1. 2010 Environmental Advisory Group Composition

Within days of the start of the response, it became evident that a multidisciplinary assembly of professionals would be required to provide scientific and technical support to assist the FOSC in making operational issues during the response. As a result, the Environmental Advisory Group (EAG) was formed to support the FOSC. The initial tasks included reviewing work plans submitted by Enbridge for different phases of the response. The purpose of these reviews was to evaluate the plans from multiple vantage points, ranging from health and safety issues to environmental impact to technical viability.

In order to ensure that the technical interests of multiple disciplines were considered during the response, the EAG was formed within the Environmental Unit of the Planning Section. Technical persons from the following entities comprised the EAG:

- EPA,
- USFWS,
- MDEQ/MDNRE,
- MDCH,
- USGS,
- NOAA,
- USDA,
- Calhoun County,
- Kalamazoo County,
- City of Battle Creek,
- City of Marshall,
- Kalamazoo River Watershed Council, and
- Enbridge.

7.5.2. EAG Activities

During the initial phase of the response, dozens of teams inspected and evaluated overbank areas for the presence and extent of oil. Although the SCAT teams were generally consistent in their makeup, establishing a consistent basis for reporting the observations was necessary to maintain an accurate accounting of affected areas. The FOSC asked that the EAG establish a uniform process for SCAT personnel to use in reporting their observations. As a result, the EAG developed a flow chart to provide a consistent set of metrics for SCAT personnel to report their observations.

Due to the type of oil discharged, in combination with the environment that it was discharged into (e.g., moving waters, warm air temperatures), the discharged oil rapidly began to appear in multiple forms, ranging from flowing oil to more viscous oil and semi-solid forms. The multiple forms of oils necessitated multiple recovery techniques. The FOSC requested the EAG to provide recommendations and evaluate various forms of oil recovery including, but not limited to: in-stream recovery (e.g., Gabion baskets with snare boom), sorbent boom, aeration, skimming, in-situ burning, oiled-vegetation removal, and dispersants. This task was appropriate for the EAG because of the various fields of science or environmental practice represented in the group, and so potentially unintended consequences of a particular recovery approach could be evaluated from multiple vantage points. An example of this multidisciplinary benefit was evaluating the use dispersants on the potential unintended consequences on living organisms in the affected waterways.

7.5.3. Scientific Support Coordination Group

As response actions progressed from gross oil removal to understanding the fate and transport of the discharged oil and associated recovery complexities, the FOSC elected to expand the efforts of the former EAG. As a result, the Scientific Support Coordination Group (SSCG) was established in 2011. The SSCG was comprised of technical experts from government, academia, and consulting fields. The FOSC considered the recommendations and advice of the individual members of this collection of scientists.

The FOSC charged the SSCG with providing technical expertise regarding: geomorphology, temperature effects on detecting submerged oil, biodegradation of remaining oil, hydrodynamic modeling, NEBA, submerged oil quantification, oil chemistry, agitation effects, statistically-based assessment methods, ebullition, and OPA. A more detailed description of each of these topics is described in Section 8.

7.6. Demobilization Unit

The Demobilization Unit was responsible for the check-out process as responders were released from the response. The process included signoff from the Documentation Unit, Finance Section, and Logistics Section to ensure that documents and e-mails were collected, time and expenses were accounted for, and borrowed equipment was returned. Lastly, the Demobilization Unit required the individual to contact them upon return to their home base to ensure that the individual safely arrived.

7.7. Resource Unit

The long duration of response activities, along with the complex technical and scientific aspects of the employed cleanup techniques, presented challenges in staffing leadership and oversight personnel to support the FOSC in directing site operations. These challenges were met by staffing the response with a combination of EPA personnel, EPA contractors, and personnel from other federal agencies.

7.7.1. EPA Personnel

EPA staff dominated the ranks of federal personnel and functioned primarily in roles that supported the FOSC’s obligation to direct response actions. Staffing was arranged by EPA’s

Region 5 Emergency Operations Center (EOC) located in Chicago, Illinois. This off-site resource center was tasked with identifying EPA personnel with the appropriate skill sets, training, and availability to meet the needs of the response. EOC staff coordinated with the other nine EPA regions to schedule and deploy EPA personnel.

During the initial phase of the response from July to December 2010, over 200 EPA staff were deployed in two to four week rotations. They generally led subdivisions of the operations and safety elements of the ICS, which were populated by Enbridge and its contractors. Some EPA staff also led operational units which consisted of EPA contractors.

As the response activity evolved in 2011 to 2014, EPA staffing changed. During this time period, EPA personnel filled the FOSC role and operational leadership positions, providing direction to Enbridge. They were supported in other oversight functions by technical assistance contract staff under EPA's START 2 contract and in scientific support by USGS, USFWS, and the U.S Army Corps of Engineers (USACE).

7.7.2. EPA Contractors

During the first few weeks of the response, EPA maintained a mobilization of ERRS contractors until it was evident that Enbridge mobilizations were complete enough to conduct all operations. During this period, each separate ERRS contractor was responsible for logistics necessary to support the operations roles that EPA tasked them to perform.

EPA relied heavily upon its START 2 contract staff for long-term support of its FOSC and FOSC representative oversight of Enbridge operations between 2010 and 2014. The START 2 contractor maintained on-site Resource Unit personnel throughout the response to manage the complex staffing needs. The Resource Unit worked closely with the Operations Section to identify individuals needed to staff the response based on the skills, training, and duration requirements of each position. Once the initial positions were filled, the Resource Unit identified subsequent staff to provide for a consistent staff base. This process evolved into a rotational staffing matrix to ensure continuity while allowing key individuals appropriate rest periods. The Resource Unit issued mobilization orders to each individual, which included instructions for travel, local transportation, and hotel accommodations. The Resource Unit was also responsible for checking in new and returning staff and directing them to their assigned leaders.

7.7.3. Other agencies and PRFAs

Other federal agencies also provided personnel including USCG, OSHA, USDA, USFWS, NOAA, USGS, NWS, and USACE. The logistical support for other agencies during the first few weeks of the response was mainly related to on-site administrative office functions and was provided by Enbridge. Long-term support for EPA from other agencies such as USCG and USGS similarly required administrative field office needs, which were accommodated within the ICP setups described above.

7.8. Situation Unit

The Situation Unit provided constant situational awareness to the FOSC and the Operations Section. The primary method of obtaining information was frequent and routine reconnaissance of the spill response area and associated areas. The primary method of documenting the observations was to provide photographic documentation of the discharge and affected areas and media. This information was useful in documenting the operations or lack of operations in affected overbank areas and submerged oil deposition locations and the degree of the affected media.

Reconnaissance was performed via foot, boat, and aerial observation (via helicopter). Helicopter flights enabled effective reconnaissance of the expansive Spill Response Area, as well as viewing and documenting sheen and oil observations. By performing routine and repeated observation of the river, Situation Unit personnel were able to develop a detailed working knowledge of the riverine system, which the FOSC and operations personnel used to drive effective responses to the discharged oil.

7.8.1. Reconnaissance

The quantity and frequency of reconnaissance was governed by the field operations and weather patterns. However, reconnaissance occurred daily for emerging sheen and oil. A sheen response flow chart was developed and utilized by the Situation Unit to report sheen and oil observations that required a response effort. Responses were communicated to operations personnel immediately and documented. In addition to regular reconnaissance, the FOSC and/or other response personnel periodically requested observations of areas of interest.

7.8.2. Response-Specific Aerial Photography

High-resolution aerial photographs of the response area were collected in August 2010, September 2010, April 2011, July 2011, and November 2011. The areal coverage for the photographic survey events was similar and extended approximately one-half mile on either side of the Talmadge Creek and Kalamazoo River waterways from the river crossing of Interstate I-69 in Marshall, Michigan to below Morrow Dam in Comstock, Michigan. This coverage encompassed the full floodplains for both water bodies over the affected reach. The data from each survey event were processed and provided to EPA and other users in electronic format as a series of separate (e.g., 2,000’ x 2,000’), georeferenced image files from which mosaics were created.

Surface oil within the river was readily visible in the aerial photos. The August and September 2010 aerial photography sets, in particular, provided valuable reconnaissance tools for assessing the distribution of surface oiling during early stages of the response. However, the presence of extensive tree and other vegetation cover along and adjacent to the waterways, combined with the timing of the August and September 2010 aerial photographs during full leaf-out conditions, prevented use of these photographs to reliably identify and map potentially significant waterway and floodplain landform features. The subsequent April 2011 aerial survey was performed during a period of leaf-off vegetation cover and approximately bank-full river discharge conditions, and photographs from this event have provided an important reference data set for locating detailed landform features present within the river and floodplain. An updated, digitized waterway boundary for the affected reach was created from the April 2011 aerial imagery, which has been used for subsequent submerged oil mapping and area determinations.

7.8.3. Documentation

Throughout the response, thousands of photographs were taken to document operations as well as oil and sheen occurrence. The Situation Unit was responsible for consolidating the photographs to a daily photographic log that was distributed to key members of the ICS. Documentation collection responsibilities for the Situation Unit included the daily collection of water and sediment temperature readings and river water level readings from designated locations throughout the river system. Patterns of oil manifestation were established and documented, along with water and sediment temperature, barometric pressure changes, and weather changes. The Situation Unit was also able to document the development and implementation of the new assessment and recovery tactics.

Photographic documentation collected by the Situation Unit was utilized and presented in various response meetings (e.g., C&G, planning, MAC, consolidated ICS, IAP briefings). In addition, photographic and video documentation were also utilized in presentations and public meetings.

7.8.4. Data Management Unit

The Data Management Unit was established to organize and maintain information, reports, analytical data, and photographs. Much of the early efforts of the Data Management Unit focused on disseminating analytical data and tying photographs to locations and operations throughout the response area.

Monitoring and sampling data were maintained in SCRIBE, a software program developed by EPA's ERT to assist in the process of managing environmental data. SCRIBE captures sampling, observational, and monitoring field data.

Monitoring data were converted to an Electronic Data Deliverable (EDD) format compatible with SCRIBE. Laboratory analytical EDDs were largely compatible with SCRIBE with the addition of validators' flags.

7.9. Existing Hydrologic Reference Data

At the time of the discharge, only limited survey/mapping data and hydraulic data were available for the affected portion of the Kalamazoo River. Specific concerns were that the extent of areas subject to flooding at the time of the discharge could not be reliably determined from the existing data. Other concerns were that incomplete or inaccurate mapping of irregular morphological features present in the affected river reach could cause significant submerged oil accumulations to be overlooked. In view of these concerns, efforts to collect additional detailed site data were initiated as part of the response activities.

Hydraulic data available for the affected river segment consisted of records from three permanent USGS stream gage stations located along the Kalamazoo River at Marshall, Battle Creek, and Comstock, Michigan. In addition to providing valuable information regarding the discharge and water height conditions at the time of the oil spill, use of these USGS gage stations has continued during subsequent response activities to provide ongoing river discharge information within the affected reach. Historical records from the three gages have also been used to shed light on the expected seasonal variation in discharge and water heights within the affected reach.

A large number of National Geodetic Survey survey monuments are located in the vicinity of the affected segment of the Kalamazoo River. MDOT also operates and maintains a statewide network of Continuously Operating Reference Stations (CORS) that broadcast Real-Time Correction Message signals needed for high accuracy survey measurements using Real-Time Kinetic (RTK) GPS instruments. These monuments and stations have been used to provide reference locations and elevations for numerous project survey tasks.

7.10. Geographical Information Systems Unit

GIS technology was used in most aspects of the response. The spatial component for data allowed for increased visualization and, therefore, better informed response decisions.

Background imagery for the GIS system included: the National Agriculture Imagery Program for October 2009 and August 2010; aerial and satellite imagery from a streaming service via ArcMap ArcInfo licenses; and Enbridge-provided post-spill, high-resolution imagery.

7.10.1. Mapping Process

The need for maps and figures at the beginning of the response was immense. Responders sought aerial maps, site plans, and location figures. In fact, hundreds of map requests were submitted to the GIS Unit daily. The 213 form served as a guide for GIS staff to create map deliverables, as well as keep records to be logged into MapTracker. The 213 GIS Product Request Form provided the GIS analysts with pertinent information about the requestor and the request.

Maps were uploaded to the EPA MapTracker on a weekly basis from the initial response period through December 2010. The MapTracker is a web-based Oracle™ Application Express solution designed to allow for the entry of GIS projects, their component tasks, metadata, and associated files allowing for easy tracking and management of GIS projects.

7.10.2. Kalamazoo River Mapping for Operations Area Mapping

Operation areas were mapped for ICS personnel on a daily basis due to the changing scope of the response. Division boundaries (A through E) served as a constant base layer and remained the same throughout the response. From the discharge entry point on Talmadge Creek down through the Kalamazoo River to the Morrow Lake Dam, the centerline for the water body spanned approximately 40 mi. The centerline was converted to quarter-mile points to create a milepost base layer that was used to identify sites and work areas by their milepost position. Locations of operating areas, field staging areas, and boom locations were mapped and updated as needed by GIS staff.

7.10.3. Ecosystem Assessment Mapping

Wildlife assessment, species concern analysis, and wetland maps were created during the initial phase of the response to aid responders in evaluating the potential toxic exposure to the surrounding landscape and ecosystem. Sensitive area locations were symbolized from classification values that ran from noteworthy to greatest critical concern. Archeological site data were also mapped.

7.10.4. Air Monitoring and Sampling Data Mapping

Air monitoring and sampling results maps were created by GIS using the monitoring data collected by field personnel. The results were classified using three to four natural breaks in the data and color-coded accordingly. Typical air monitoring and sampling maps included base layers such as: imagery, boom locations, evacuation/reoccupation zones, divisions, and the approximate discharge site. Grid analysis maps were created from benzene readings. Benzene readings per grid were aggregated, and the grids were assigned a status (color-coded) from the benzene concentration. Grid analysis for benzene concentration maps were created and represented: minimum/maximum values, average values, and percent of detections.

7.10.5. Sediment/Surface Water Sampling Mapping

Three general map types were created for sediment and surface water sample results: 1) surface water/sediment sample locations and results, 2) validated surface water sample locations and results, and 3) sediment sample detection maps. Analytical results were presented in call out boxes, and various symbologies were used to denote different sample media (e.g., surface water, sediment) and analytical results status (e.g., preliminary, final).

7.10.6. SCAT/SORT Mapping

The SCAT program used standardized terminology to document shoreline oiling conditions.

Four map types were created from the collected field data provided by the SCAT teams: 1) photo location maps, 2) pooled oil maps, 3) SCAT data overview maps, and 4) SCAT waypoint division maps.

SORT teams surveyed the shorelines along the spill path and recorded observations using GPS-enabled personal digital assistants. Point locations for sheen observed, staining/other, oil observed and no oil observed were collected. Various symbologies were used to differentiate these observations and allowed operations personnel to rapidly obtain an overview of areas requiring response.

7.10.7. Data Exchange Policies/Process (Enbridge and EPA)

EPA directed Enbridge to provide non-proprietary spatial data used in the creation of maps and graphics pertaining to the response. The first major data from Enbridge were delivered to EPA via hard drive and included spatial data in file geodatabase format. The initial data deliverable contained imagery collected, base layers used for map creation, and field data obtained prior and through the Spring 2011 Reassessment.

After the Spring 2011 Reassessment, Enbridge provided weekly data updates appending new data to current geodatabases as field operations continued. GIS data layers were tracked via a spreadsheet that accompanied data deliverables.

7.10.8. Submerged Oil Assessment Mapping

Submerged oil maps were created using results of poling. Field observations and sample locations from poling activities were recorded using Leica RTK type (e.g., carrier-phase) differential GPS instruments, and reference ground signal was supplied by the CORS station network operated by

MDOT.

Information that was recorded included: location (including milepost), weather, depths (water and sediment), sheen observations, time, water/sediment temperature, vegetation/bed type, and metrics to describe the amount of sheen observed during poling. Polygons were created around discrete areas to classify areas of similar poling results and identify response features such as sediment traps and conifer structures.

GIS data for eleven submerged oil poling categories were used to create maps. The assessments included: 2010 Post Spill Assessment, 2011 Spring Reassessment, 2011 Late Summer Reassessment, 2011 Summer Recovery, 2011 Monitoring, 2012 Spring Reassessment, 2012 Fall Reassessment, 2012 Monitoring, 2013 Spring Reassessment, and 2013 Monitoring.

Time-series animations were also produced from poling results using ArcMap. The time-series feature was used in a live GIS setting that could dynamically display submerged oil results. The swipe tool was also utilized in a live GIS setting for more detailed and larger-scale comparisons of poling results for two different time periods. These features were used extensively during meetings and briefings.

7.10.9. FLEX Web-Viewer

In early 2013, EPA introduced a FLEX-based web viewer to streamline the GIS data in a live environment. The web viewer was secure and available to required personnel. The FLEX viewer was designed with a simple interface that included a layers window, widget icons, and nine different basemap options. The layers window was created using a basic drop-drown window design in which the user could check on or off the layer and control transparency, as well as the option to zoom to layer.

7.10.10. Supplemental Topographic and Bathymetric Data

Aerial LIDAR data collected in early 2010, prior to the oil spill, were provided to EPA and other government agencies through Calhoun County representatives serving on the MAC. The LIDAR data provided detailed land elevations, with sub-one foot accuracy, for floodplains and islands adjacent to the affected waterways located in Calhoun County. The availability of the supplemental LIDAR data was instrumental in allowing the upper-river flood inundation modeling work to be done, thereby also demonstrating the feasibility of using this approach.

In August to September 2010, in preparation for the initial flood inundation zone mapping, USGS personnel collected supplemental survey measurements for bridges and dam features located in the upper segment of the Kalamazoo River affected by the discharge, as well as bathymetric elevations along representative upper-river transects. The bathymetry transects were completed upstream and downstream of bridges and at representative locations along the river.

Other supplemental data acquisition in August and September 2010 included exploratory sonar bathymetry for Morrow Lake and a set of longitudinal bathymetry measurements made along the affected reach of the Kalamazoo River from Talmadge Creek to Morrow Dam. Single-beam sonar coverage was completed for the entire lake except near Morrow Dam, where the dam operator would not allow use of the equipment, and a few near shore areas where the water depth was too shallow to obtain meaningful measurements. It should be noted that Enbridge's original intent was to acquire sonar bottom elevation measurements throughout the affected river system, including Morrow Lake Delta. However, the shallow water depths occurring in 2010 prevented the use of the sonar equipment upstream of the neck portion of Morrow Lake Delta. Processing of the sonar data primarily consisted of compiling and interpolating the point measurements to create a continuous five ft by five ft raster of bottom elevations for Morrow Lake and the neck. The longitudinal bathymetry survey consisted of joint measurements of water surface elevation and water depth at discrete distance intervals along the estimated river thalweg (i.e., deepest point in the river channel). The longitudinal bathymetry survey data were used to document the river gradient within sub-segments of the affected river reach.

Following successful completion of the upper-river flood inundation zone modeling and mapping by USGS in late 2010, Enbridge proceeded to collect the additional site data required to perform a similar flood inundation zone analysis for the lower river during the spring of 2011. The additional site data for this purpose included separate aerial LIDAR coverage of the Kalamazoo River floodplain over the full length of affected reach, supplemental survey location and elevation measurements for lower river bridges, and bathymetry measurements along select lower-river transects. The methods used for collection and analysis of the lower-river site data were generally similar to those used for the upper river. One exception was that the end product of the LIDAR data processing consisted exclusively of one-foot elevation contours. While the resultant data were adequate to complete the lower-river flood inundation modeling, the elevation trends indicated by the one-foot contour data were more difficult to interpret, particularly in low-relief floodplain and island areas.

7.11. Documentation Unit

The NCP requires the FOSC to complete and maintain documentation to support actions taken under the NCP, support cost recovery for resources utilized, and identify impacts and potential impacts to public health and welfare and the environment. In addition to the NCP requirements, EPA issued a litigation hold for response documentation in anticipation that litigation for costs, damages, and penalties was likely. The litigation hold required preservation of potentially relevant information, including electronically stored information (ESI) and hard copy documentation, whether original or duplicate, draft or final versions, or partial or complete versions. The types of information to be preserved were not limited to federal records or official government files and also included site-related personal files such as notebooks, calendars, and day planners.

7.11.1. Initial Document Retention (July – September 2010)

On July 30, 2010 the EPA Deputy Regional Counsel distributed a memorandum to EPA personnel involved with the site to inform them of their obligation to preserve potentially relevant information under the litigation hold. The memorandum specifically detailed the types of information that must be preserved.

Between July and September 2010, the FOSC directed the Documentation Unit to focus on retention of documentation in accordance with the litigation hold. Collection boxes were distributed throughout EPA's, MDEQ's, and assisting agencies' areas of the ICP.

7.11.2. Documentation Standard Operating Procedure

In October 2010, the FOSC directed the Documentation Unit to coordinate with EPA Region 6 personnel and EPA Region 5 Records Center personnel to develop a standard operating procedure (SOP) for the processing of hard copy and ESI documentation. The resulting SOP was prepared and implemented to ensure unique site-related documents were indexed and converted to electronic format for upload to the Superfund Document Management System (SDMS). Over 31,000 documents consisting of over 1.4 million images have been submitted to the EPA Region 5 Records Center for upload into SDMS.

7.11.3. Hard Copy Document Retention (October 2010-Present)

In accordance with the Documentation Unit's SOP, response personnel were instructed to record their name and the date on documents they authored or reviewed and to place hard copy documents in the documentation collection boxes. Following collection, the Documentation Unit sorted the documents to identify true duplicates for shredding. Documents were only shredded after comparing the document page by page to ensure an identical document existed. SDMS document ID barcode labels were affixed to the right bottom corner of the first page of each unique document.

Unit Identifier Codes (UICs) were assigned to each Division, Branch, Group, and Team identified in the IAP organizational charts. The Documentation Unit wrote the appropriate UIC on the right upper corner of the first page of each unique document to identify the functional component that produced each document, facilitate the rapid retrieval of relevant-response documentation, and allow the development of a logical structure for identification of costs and resources required and assigned.

Each unique document was indexed according to the Region 5 indexing guidelines to identify fields such as the SDMS document ID barcode number, document date, title, document type, author, addressee, UIC, and physical location of the corresponding hard copy native document. The excel index was used as the inventory of documents collected and processed, as an aid for document retrieval, and as the vehicle for uploading and updating metadata into SDMS.

On-site Documentation Unit personnel scanned hard copy documentation according to the standard criteria for SDMS upload. Oversized documents were scanned at an off-site facility. Following scanning, Optical Character Recognition (OCR) processing was conducted in order to make the PDF files searchable. Page rotations and bookmarking were conducted to assist the end user's ability to navigate through larger documents. Documentation Unit personnel conducted a quality control review of the scanned documents to ensure the index metadata, the PDF file, and the paper document correctly corresponded.

7.11.4. Electronic Document Retention (October 2010-Present)

In August 2010, network-attached storage (NAS) units were established by the Communications Unit Leader to provide data access for on-site response personnel. The NAS Units were divided into folders by ICS Section. In December 2010, the FOSC directed the Documentation Unit to process electronic files stored on the NAS prior to December 1, 2010 for upload to SDMS. All files within this file structure were made read-only, and a new active location was established on the NAS for site use. The new folder structure consisted of a single folder for each UIC.

The Documentation Unit assigned UICs to electronic documents by moving them to the appropriate UIC folder. Electronic documents were considered duplicates when two electronic files had identical file names, file sizes, modified dates, and modified times. Only true duplicate files were deleted. The Documentation Unit assigned barcodes to electronic documents by inserting the SDMS barcode number into the file or folder name of the native format document.

Each unique document was indexed according to the Region 5 indexing guidelines. The index fields were identical to the indexing for hard copy documents with the exception of capturing the source information of the native electronic file.

Each electronic document was converted to a PDF file. Following conversion, OCR processing was conducted in order to make the PDF files searchable, and electronic barcodes were added to the PDF file. Page rotations and bookmarking were conducted as necessary to assist the end user's ability to navigate through documents.

Documentation Unit personnel conducted a quality control review of the converted documents to ensure the index metadata, the PDF file, and the electronic document correctly corresponded.

Due to performance and storage requirements, the NAS Units were replaced with an EPA server in May 2012. Both the NAS Units and the server were routinely backed up throughout the response.

7.11.5. E-mail Document Retention (October 2010-Current)

Incident response e-mail boxes were established at the beginning of the response. The FOSC directed site personnel to copy the incident e-mail boxes on all official communication for the incident.

A Lotus Notes collection database was established for collection of EPA personnel e-mails. In December 2010, the Region 5 Associate Regional Counsel distributed instructions to relevant EPA personnel for archiving e-mails and electronic documents related to the site litigation hold. The instructions were redistributed multiple times throughout the response.

7.11.6. Protected Information

The FOSC instructed field and command personnel to hand deliver and clearly identify any documentation containing confidential information, including confidential business information (CBI), to the Documentation Unit. Upon receipt, the Documentation Unit locked the documents in a secure location. An individual experienced in CBI and sensitive documentation procedures scanned and processed CBI documents directly to a compact disc, rather than to the NAS or the server. Copies of the compact disc were retained on site in a secure location. A copy of the compact disc and corresponding hard copy documents were transported under chain of custody to the EPA Region 5 Records Center.

Prior to releasing any document to the public in response to a specific Freedom of Information

(FOIA) request or by posting to the EPA website, the FOSC directed the Documentation Unit to redact protected information such as personal information, financial or business sensitive information, proprietary trade secrets, and CBI. In November 2011, redaction specialists began prioritization, review, and electronic redaction of confidential information from documents.

7.11.7. Release of Documentation to the Public

FOIA requests were handled by the EPA Region 5 FOIA Specialists. EPA identified responsive documentation from SDMS and the Lotus Notes collection database and through coordination with site personnel to identify documents had not yet been submitted to the databases.

Approved Enbridge work plans and reports, associated EPA correspondence regarding the approved documents, data, and other information were routinely posted on the EPA website to allow access to the general public and to minimize costs associated with potential FOIA requests.

7.11.8. Administrative Record

In support of EPA's October 3, 2012 proposed Order for Removal to Enbridge, the FOSC directed the Documentation Unit to prepare a draft Administrative Record. The Administrative Record included documents that were used by the FOSC to determine the federal response action, including photos, videos, logbooks, data, correspondence, GIS maps, guidance documents, and regulations. The draft Administrative Record contained more than 1,100 documents totaling more than 110,000 pages.

Prior to issuance of EPA's March 14, 2013 Order for Removal to Enbridge, the FOSC directed the Documentation Unit to revise the draft Administrative Record to include additional documentation generated after issuance of the proposed Order and documentation of EPA's response to Enbridge's comments on the proposed Order. The Administrative Record contained more than 1,700 documents totaling more than 148,000 pages.

7.12. FOSC Commentary on the Effectiveness of the Planning Section

Most importantly, the success of this response hinged upon EPA's ability to foster an effective response organization throughout the changing demands of the response. The Planning Section proved to be effective and adaptable through the following distinct phases of the response:

- Crisis Phase: By days four and five of the response, a strong ICS /UC effort was underway. Strong Planning Section work was key. Although initially lead by EPA, EPA directed Enbridge to assume responsibility for this under EPA's guidance once the Planning Cycle and IAP development were solidified. Enbridge retained ICS response consultants to assist in these efforts. USCG and USFS personnel provided great support to these efforts.
- Initial Recovery Phase: Sustaining the UC throughout the first several months of the response helped ensure that all local and state stakeholders were aware of the progression of the response. This also ensured that EPA and Enbridge were aided by those same jurisdictions as necessary. The continuing integration of EPA and RP Planning Sections fostered this.

- Sustained Response Phase: In the ensuing years (one to five) of the response, these coordination functions were achieved by Enbridge and EPA remaining in a formal ICS response organization (UC), which interacted with other stakeholders via MAC process and eventually via a Stakeholder Group.

Other Planning Issues

The need for local, high-speed printing capabilities was essential in the early stages of the response when the IAP was produced and distributed daily. This was ultimately fulfilled by using a commercial print service paid for by the RP and should be an early consideration as resources to print these daily can be quickly overwhelmed.

The photographs in the situation updates were an invaluable tool for documenting river conditions and response activities on the river. The photographs provided indisputable documentation of conditions, ground truth for EPA reports, and in many cases, were used to verify the observations reported by Enbridge. This function should always remain in the control of the lead agency, as oversight of this role may be insufficient to keep perceptions from being manipulated. The agency should retain the responsibility of situation updates to ensure accuracy.

Another critical function that eventually fell mainly on the Situation Unit was collection and assemblage of key response metrics for report out in each planning cycle, and sometimes several times within each cycle. The FOSC should plan for and request resources whose primary task in the Situation Unit is to track and maintain these metrics in as close to real-time availability as possible. This avoids diverting the FOSC and operations staff from their primary work and planning cycle to gather this data.

Consistency in staffing the Situation Unit was critical in maintaining the consistent observations and documentation. This consistency proved to be useful in locating and documenting oil throughout varying flow and weather conditions. In addition, information gained from the aerial overflights better enabled situation personnel to locate areas of interest when performing land and/or boat-based observations.

In a response of this magnitude, a single point of contact for FOIA requests was critical for tracking and ensuring compliance. This should be initiated at the start of future responses.

GIS files should be maintained separately by the agency for verification. Updated files need to be provided to the agency periodically. This ensures the accuracy in the geospatial representation of the data.

Documentation is a critical function, and EPA litigation specialists must be active and engaged as early as possible for the best implementation of litigation holds on large responses. This will ensure that litigation hold procedures are understood and that the Documentation Unit knows which files (electronic and hardcopy) need to be tracked and maintained. It is of high importance that the EOC communicates routinely with the FOSC and senior EPA staff to not only ensure that the appropriate number of personnel resources can be ordered to the site, but that those resources are appropriately trained and competent to conduct the work they are being sent to do. Staffing, especially early in the response, should be highly coordinated to ensure adequate resources and personnel to support the response efforts.

8. Science-Based Support of the Response

The removal of gross quantities of oil using conventional methods was effective during the initial phases of the response, when more than an estimated 766,000 gallons of oil were recovered. However, reassessment activities performed after the initial phase of the response confirmed the presence of submerged oil throughout the affected portions of the Kalamazoo River. Due to the extent of submerged oil detected in the affected waterways in 2011, additional science-based initiatives were necessary to understand the distribution and characteristics of the remaining submerged oil. Therefore, the FOSC directed several scientific-based initiatives to provide information necessary to equip the Operations Section with technically sound information on which to base future response actions.

The FOSC science-based directives examined several lines of evidence to develop a better understanding of the remaining oil. These multiple lines of evidence helped define the extent, fate, and transport characteristics of the remaining oil and ultimately better equipped the FOSC to direct the final response strategy via dredging of impoundments and sediment traps to remove the remaining oil.

The major scientific initiatives directed by the FOSC during the response are described below.

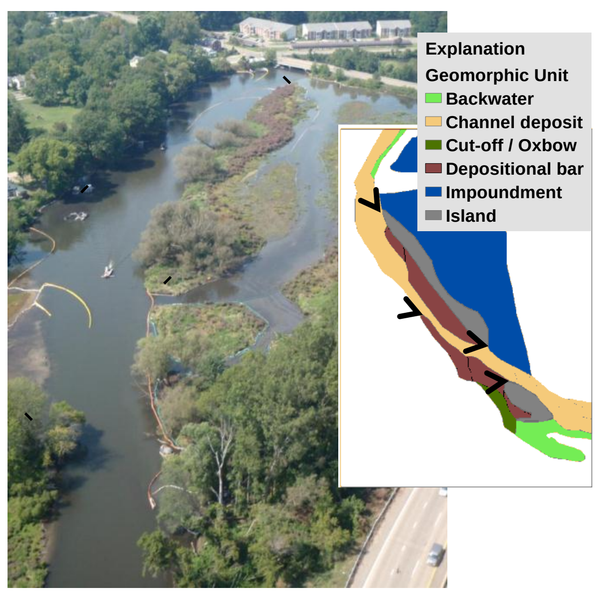
8.1. Geomorphology

An understanding of the geomorphic characteristics of the Kalamazoo River provided the backbone for submerged oil assessment, monitoring, and recovery activities because of submerged oil's association with depositional areas of the river and affinity for aggregation with fine-grained sediment (silt, clay, and organic matter). These particles, associated with depositional areas in the river, had important direct and indirect roles in the formation of OPA from the mixing of bitumen with the sediment. As the initial mass of oil broke up and formed droplets, the bitumen had a high affinity for silt, clay, and organic matter in suspension in the water column, as well as on the river bed and banks (Figure 99). While the range of mechanisms for the formation of OPA in freshwater riverine environments are being investigated in laboratory studies, the geomorphic and sediment conditions in the Kalamazoo River were especially conducive to the formation of OPA. The resuspension, transport, and settling of OPA were also studied in laboratory flume tests to obtain data inputs for numerical models aiding in the Kalamazoo River cleanup . Similar to fine-grained sediment and organic matter, OPA can be deposited in low gradient areas of the main channels, such as in impoundments, during low flows, but then during high flows these areas can become erosional, corresponding to increased velocities. Some areas of the river are always depositional even under high flow conditions, such as offchannel backwaters in wide sections of the river or disconnected side channels and oxbows. Other areas may be depositional during low flow, but with high flows, soft sediment and remaining oil, and OPA may be transported downstream.

Figure 99 – Oiled Sediment and Emerging Sheen from Oiled Sediments

Areas of slow-moving water containing submerged oil included reaches where the slope of the river flattened, such as at the three main impoundments (Ceresco Dam, Mill Ponds, and Morrow Lake Delta), or where the river widened enough to allow for depositional zones along channel margins. Submerged oil also was associated with secondary channels, oxbows, the downstream side of islands, and tributary mouths.

Figure 100 – Geomorphic Units, Mill Ponds



The mapped geomorphic units (Figure 100) first delineated in 2010, along with associated sediment substrate types, were used as a basis to form: 1) the habitat types used in the NEBAs described below and 2) the geomorphic strata used in the quantification of the volume of submerged oil remaining in the river, also described below. In addition, the geomorphic strata formed the boundary conditions for bed substrate used in hydrodynamic modeling of oiled sediment transport in the Kalamazoo River.

8.2. Temperature Effects Study

Anecdotal reports in the fall of 2011 and 2012 indicated that surface manifestations of oil (sheen and tar globs) appeared to diminish as ambient water temperatures became colder. While it was always possible that the observed decrease in manifestation of surface oil was attributable, at least in part, to the success of previous oil recovery efforts, the FOSC wanted to know if there was a potential link between decreased surface oil manifestation and decreased temperature of river water and sediment. This was of particular importance because the primary method of locating and categorizing remaining submerged oil was poling, which relied on the ability of submerged oil to manifest on the water surface upon manual agitation. In essence, the FOSC desired to know if the poling results were less reliable during times of decreased temperatures in river water and sediment.

The FOSC directed Enbridge to prepare a work plan and perform investigations to examine the effects of temperature on the release of submerged oil from sediments. Two separate investigations, as summarized below, were performed.

1. An in-situ investigation known as the Temperature Effect Monitoring Station (TEMS) Study was performed. In this study, Enbridge selected nine Kalamazoo River locations in the general vicinity of MP 36.5 known to contain submerged oil as test locations. Temporary enclosures were installed at each of these locations to isolate the sediment and associated submerged oil. The enclosures covered nine square ft (three ft by three ft). The TEMS were repeatedly visited and poled during October 2011 to observe and document the ability of sediment agitation to produce oil sheen and oil globules while the river water and sediment temperatures were undergoing typical seasonal temperature decreases. During the period from October 14, 2011 to October 29, 2011, sediment bed surface temperatures generally decreased over a range from 60.2 °F to 43.7 °F.

2. A bench-scale study was performed to observe and document the effect of water and sediment temperatures on the release of submerged oil upon agitation. Oil-containing sediments were collected from MP 10.75 for this study. Sediment and river water samples were collected on December 19, 2011 and stored at 34 °F until use. Sediment and river water aliquots were placed into beakers and allowed to equilibrate in a temperature-controlled water bath. Test temperatures ranged from 35 °F to 75 °F, which represented the observed temperature range of water and sediment in the affected reaches of the Kalamazoo River. After the sediment and water had reached the test temperature, the sediments were agitated with a glass rod, and observers recorded the presence and level of sheen and globule manifestation to the water surface. Samples were examined under visible and UV light.

Upon completion of these two studies, Enbridge submitted the "Report of Findings for Submerged Oil Temperature Effects Study, February 20, 2012" to EPA for review.

The TEMS Study was, unfortunately, negatively affected by the late start of the study, as seasonal temperatures had already begun to decline and only allowed sediment temperatures ranging from approximately 60 °F to 45 °F to be examined. In addition, due to the timing of the study, only 14 rounds of data were collected.

During the bench scale test, aliquots of submerged oil-containing sediments and river water were agitated at target temperatures of 35 °F, 45 °F, 55 °F, 65 °F, and 75 °F. Very little sheen and globules were observed at temperatures below 55 °F. In the range of 55 °F to 65 °F, there was notable increase in the quantity of sheen and globules released. An even greater amount of sheen and globules was observed at 75 °F.

Although 75 °F was a preferred minimum temperature for assessing submerged oil via poling, water and sediment temperatures rarely reached 75 °F for sustained periods of time. As a result, waiting for temperatures of at least 75 °F would have prevented a continuous assessment of submerged oil conditions in a given period. Therefore, the FOSC directed that future poling assessments be performed when water and sediment temperatures were at least 60 °F so that the assessment could be performed in a timely fashion that supported recovery operations during the construction season.

8.3. Biodegradation Evaluation

At the time of the discharge of the Line 6B diluted bitumen, there was minimal scientific information available regarding the fate and transport of diluted bitumen in the freshwater ecosystem of Talmadge Creek and the Kalamazoo River. At the request of the FOSC, EPA's ERT performed a bench-scale screening level study to examine the biodegradability of residual Line 6B oil. The primary objective of the study was to determine if residual Line 6B oil could undergo biodegradation, beyond the weathering and in-situ degradation that had occurred since the discharge.

Biodegradation of residual oil is a well-established process that occurs on discharged oil. However, this process is usually limited to aerobic systems and typically involves the use of land farming enhancement techniques or batch treatment cells to stimulate the degradation. During the biodegradation process, rapid degradation of oil components occurs on the straight chain hydrocarbons (n-alkanes) and lighter end compounds, which typically dominate refined oil products. Many crude oils contain a significant percentage of easily degradable light ends and straight chain hydrocarbons.

The chemical composition of the Line 6B oil mixture is different than typical crude oil because it is a DilBit and contains large amounts of branched and heavy hydrocarbons, as well as asphaltenes. As a result, the composition of Line 6B DilBit makes it much more resistant to biodegradation.

8.3.1. Biodegradation Test Procedure

The first step in a biodegradation assessment is to determine if the subject material is fundamentally degradable at a rate or percentage, which could make biodegradation a viable response remedy. EPA's ERT conducted a screening-level biodegradation study to determine the biodegradation potential of oil released from Line 6B under idealized conditions in the laboratory.

Kalamazoo River sediment and a soil known to contain organisms capable of degrading oil as the inoculum were used during the ERT biodegradation evaluation.

Several sources of Line 6B oil were evaluated for inclusion in the biodegradation study. After examination of the Line 6B oil samples available, ERT selected two for this study:

- 0003: This sample represents the Line 6B oil that was recovered at the water surface over the first few weeks after the discharge and was stored by Enbridge at their facility in Griffith, Indiana.

- 0004: This sample was collected from an overbank excavation near the Kalamazoo River at MP 13.40 on February 16, 2012. This residual oil was highly viscous and believed to be mechanically weathered within the Kalamazoo River.

A nutrient mixture and recovered Line 6B oil were then added to each of the sediments/soils. The biodegradation tests were conducted for 28 days, with samples tested at day 0, 14, and 28. Degradation was evaluated through the use of a combination of gravimetric evaluation, TPH analyses, and gas chromatography/mass spectrometry (GC/MS) oil fingerprinting analyses. Additional interpretation of the biodegradation potential of the residual oil was made from the evaluation of GC/MS oil fingerprinting analyses on samples of oil recovered during the oil spill response, oil from the spill recovered from sediment samples from the Kalamazoo River, and from literature available on the crude oil source.

ERT performed the biodegradation studies between March 1, 2012 and April 18, 2012. The studies evaluated biodegradation under optimal conditions with respect to nutrients, oxygen, temperature, oil-degrading microorganisms, mixing, and oil solubilization using surfactant. ERT documented the test procedure and results in a report dated June 25, 2012.

8.3.2. Biodegradation Test Results

ERT arrived at the following conclusions when evaluating results of the biodegradation study:

- Even under optimum biodegradation conditions, only approximately 25% of the Line 6B oil was degraded.
- Under optimum conditions, the majority of the Line 6B oil that was degraded over the 28-day test period was degraded by day 14. Biodegradation continued after day 14, but at a greatly decreased rate.
- Under actual river conditions, biodegradation of residual Line 6B oil in the Kalamazoo River would have the potential to continue but at a slower rate than that observed in the test conditions, with the maximum amount of oil removed via biodegradation limited to roughly 25% of the current residual mass.

As a result of this study, biodegradation was not considered a viable stand-alone response option for the recovery of Line 6B oil.

8.4. Hydrodynamic Modeling

Hydrodynamic modeling was an integral part of the “multiple lines of evidence” approach used by the FOSC throughout the response. Model results for velocity and bed shear stresses, as well as preliminary distributions of sediment erosion and deposition, helped to answer questions about the fate and transport of remaining submerged oil in the Kalamazoo River and whether the oil could migrate out of the Morrow Lake Delta and past Morrow Dam. The modeling served an important purpose of being able to extend the range of flow conditions that had been observed in the time since the discharge. It also helped to answer “What if?” type of questions such as:

- Would a 10-year flood have the capability of resuspending oiled sediment and submerged oil in Morrow Lake Delta, and where would it redeposit?
- Where will submerged oil likely accumulate during low flow conditions?
- What happened to the submerged oil during the May 2011 flood?

The modeling was also used to assess the potential effectiveness of enhanced sediment traps and containment arrangements in Morrow Lake Delta.

The modeling work took on two phases of activities: preliminary models developed by Enbridge in 2011 to 2012 and updates and expansion of modeling by EPA in 2013 to 2014, after Enbridge declined to continue the model development. The preliminary set of hydrodynamic and sediment transport models were developed from two-dimensional (2D) Environmental Fluid Dynamics Code (EFDC) to simulate river water levels, flows, velocities, shear stresses, sediment loads, and erosion and deposition rates along the 38 mi of the Kalamazoo River from it confluence with Talmadge Creek to Morrow Dam (Enbridge, 2012e, f). A main assumption of the preliminary 2D EFDC model was that the physical properties of clay and silt-sized fine-grained sediment could be used as a surrogate for submerged oil and oiled sediment. The preliminary model was assembled very quickly, within a three-month window. The well-assembled, organized, and geo-referenced existing and new data sets made this possible. Modelling updates and expansion in 2013 to 2014 by EPA included corrections and updates to the preliminary 2D EFDC hydrodynamic models, addition of three-dimensional (3D) EFDC hydrodynamic and particle tracking models for Morrow Lake to incorporate wind and Morrow Dam effects, a more detailed 2D model for selected sediment traps, and incorporation of OPA characteristics into a new sediment transport algorithm.

For the preliminary Enbridge 2D EFDC models, two base models were created: one for in-bank flows, called the riverine model, with a boundary fitted curvilinear-orthogonal horizontal grid network, and another for out-of-bank flows, called the floodplain model, with a finer-scaled Cartesian grid network consisting of cells of approximately 49 ft by 49 ft. These base models were assembled from new and existing data collected through the fall of 2011. Boundary conditions were established using available stream flow data at five USGS stream gaging stations along the Kalamazoo River and its tributaries between Marshall and Comstock. Suspended sediment concentration and particle size data were not available for the stream gages in the modeled reach and had to be assembled from a larger geographic area of representative locations on upstream and downstream stream gages on the Kalamazoo River and on adjacent streams. Some sediment transport parameters were estimated from existing published literature. Bathymetry data were generated from poling data points combined with surveyed longitudinal profile points, single beam survey of Morrow lake bathymetry conducted in September 2010, channel cross sections measured for the Hydrologic Engineering Centers River Analysis System (HEC-RAS) modeling, and flood inundation mapping. For floodplain topography, one-foot contours were generated from the 2011 LIDAR data used in the HEC-RAS modeling and the flood inundation mapping for the entire area within the 100-year floodplain boundary (AECOM, 2011a, b). Bank lines for the riverine grid were established in GIS from November 2011 aerial imagery raster files at a scale of 1:100. Streambed characteristics for particle sizes were applied to the grids from 2011 surficial core data assigned to specific geomorphic mapping units and supplemented with substrate types recorded in poling assessments.

In the spring of 2012, the Enbridge hydrodynamic models (HDMs) were calibrated to discharge, water-surface elevation, and velocity using USGS data from stream gages and other measurements collected by Enbridge and USGS in 2010 and 2011. Erosion and sedimentation rates and sediment loads could not be calibrated because sediment data were not available; however, outputs were visually checked against depositional areas mapped in the geomorphic surfaces unit maps. Model sensitivity analyses were performed on several input parameters to assess how small variations might affect model outputs. Results from these analyses indicate that the models were most influenced by flow and bathymetry.

The updated and expanded 2013 to 2014 EPA models were needed to answer continued questions about submerged oil and OPA resuspension and deposition, containment, and oil recovery strategies. The EPA modeling was done by a team of scientists and modelers from academia, government, and consulting firms. Three sets of models were developed: updated 2D EFDC hydrodynamic and sediment transport models for the full reach of the oil-affected Kalamazoo River; new 3D EFDC hydrodynamic and particle tracking models of Morrow Lake and Morrow Lake Delta that accounted for wind and subsurface withdrawals through power plant turbines at Morrow Dam; and new HydroSed2 models for selected sediment traps with a flexible triangular-shaped grid that helped define the complexity found in side channels, backwaters, and oxbows. Consistent input data sets were used among the EPA models, and outputs were integrated in a GIS to areas of the river with moderate and heavy oiling conditions.

The three updated and expanded sets of models included more detailed bathymetry; updated tributary flow contributions; updated dam configurations for the Ceresco, Kalamazoo, and Morrow Dams; updated channel and floodplain roughness; checks of suspended sediment concentrations; and particle sizes and sediment transport parameters. A range of flows were simulated including summer low flow (July 2013), spring high flow (April to May 2013, floods with a four percent exceedance probability similar to July 2010), elevated base flow (October to November 2011), and a flood with a one percent exceedance probability. Inclusion of wind data in the 3D model was important because much of Morrow Lake is less than six ft deep, which allows for wind to set up strong vertical circulation cells with upwelling and downwelling.

Additional data collected in 2012 and 2013 were used to calibrate and validate the new models. The additional data included: Morrow Lake Delta and Morrow Lake stage data collected from April 2013 to October 2013, which was used to augment water level data at Morrow Dam obtained from STS HydroPower, Ltd.; velocity and discharge measurements collected in April to May 2013 during a spring runoff event; and suspended sediment and particle size data collected from August 2012 to April 2013 at the five USGS gages in or near the oil-affected reach of the Kalamazoo River.

A simple OPA transport algorithm was developed to represent the resuspension and deposition properties of OPAs in the 2D and 3D EFDC models. The OPA algorithm was added to the sediment transport module of EFDC. The algorithm assumes that the OPA is in a steady-state form and already part of the deposits in the river bed. OPA properties were based on observational field evidence from sediment cores, poling, and sheening globs; field-based sedflume and in-situ flume studies of oiled sediment conditions; Line 6B oil concentrations from 2012 sediment cores; and laboratory flume studies of the transport of mixes of weathered Cold Lake Blend and Kalamazoo River sediment, as well as the overall properties of Cold Lake Blend.

The updated EPA models results were used for recovery strategies, containment, and determination of endpoints through 2014, including the FOSC's decisions for dredging.

8.5. NEBA

A NEBA was developed in the spring of 2012 for remaining areas of submerged oil in the Kalamazoo River. The NEBA was based on individual recommendations and opinions from the SSCG (NEBA Conceptual Design, August 8, 2012; document and appendixes; AR-0963). This approach allowed for the relatively quick assembly of available ecological data after human health and safety factors were accounted for and resulted in timely information to continue to inform operations. The NEBA's conceptual design assisted the FOSC with balancing the ecological risks associated with leaving the residual submerged oil in place, assuming that Line 6B oil would attenuate in the Kalamazoo River sediment conditions, and the risks associated with removing the oil with selected recovery actions. Using Efroymson et al.'s (2003) application for and marine environments and Rayburn et al.'s (2004) application for oil spill planning in the Great Lakes as guides, a new NEBA conceptual design was developed for the submerged oil that remained in 2012. After the conceptual design was completed, the NEBA was applied to individual tactical areas of the river having moderate and/or heavy submerged oil amounts based on poling results. The application was repeated as new poling results and tactical areas were updated from fall 2011 through fall 2012.

The NEBA conceptual design resulted in relative risk matrices for eight recovery actions (Table 11) that encompassed eight habitat types (Table 12) and six ecological resource categories (Table 13). The possible recovery actions included the full range of recovery techniques used to recover submerged oil on the Line 6B response since the time the spill occurred. Major habitat types included channel and floodplain areas and were derived from geomorphic surface unit maps generated by Enbridge during the oil spill and from the existing National Wetlands Inventory. Species-of-concern lists were generated for each habitat type and resource category. For example, several species of turtles occupy a variety of habitat types in the Kalamazoo River. Risk of exposure via five pathways (aqueous exposure, sediment exposure, physical trauma, physical oiling/smothering, and indirect) were considered for magnitude of impact and length of recovery.

Table 11 – Major Recovery Actions Under Consideration for Submerged Oil Recovery

Recovery Action	Description
Monitored natural attenuation	Requires no active recovery but relies on natural attenuation and biodegradation. Unknown effects from oil toxicity and smothering. Unknown rates of biodegradation and weathering.

Enhanced deposition and recovery	Used in depositional areas where submerged oil is allowed to accumulate naturally or enhanced through placement of structures. Increased monitoring is done with poling assessments and sedimentation samplers. Dredging/hydrovac is likely done once after accumulation reaches desired amount. May need repeated dredging into the future, as needed; maybe about every six months in some places or after a flood.
Agitation toolbox	Used in depositional areas, various mechanical devices are used to agitate the surface including jets, chain drag, and rototiller. Involves removing aquatic vegetation and large wood in shallow areas before application. Typically disturbs the top one to two ft of material, depending on the thickness and water content of soft sediment. Involves heavy airboat traffic (noise and bank erosion) for agitation and associated sweeping. Oil/sediment plume affects turbidity and smothering to downstream areas.
Dredging/vacuum truck	Used in depositional areas, dredging or vacuum removal likely performed once or as needed. Typically removes top 0.5 to two ft of material. Most aquatic vegetation and roots removed.
Dewater/excavate	Used in shallow water or frequently inundated areas near channel margins, wetlands, and floodplain environments.
Sweep/push	Sweep/push by agitation toolbox of areas within the main river channel, with remobilization of oiled sediments to downstream sediment traps or impoundments. Uses hydrovac, dredging, or agitation toolbox for removal.
Scraping	Scraping is limited to the surface layer (<six inches) only during low water events (summer). Usually in mudflat areas with limited vegetation.
Sheen collection	Passive sorbents deployed by staking on bank/anchoring in water. May employ multiple types and arrangement of boom, some specific for sheen more so than oil droplets. Some done by sheen sweeping boats.

Table 12 – Major Habitat Types Used in the Development of the Kalamazoo River NEBA

Major Habitat Type	Definition and Examples	Percentage of Total Area

Major Habitat Type	Definition and Examples	Percentage of Total Area
Impounded waters and associated deltas	Depositional areas of standing water or slow moving flow in the Ceresco impoundment, Kalamazoo millponds, and Morrow Lake Fan and Delta. May include mudflats along margins (areas of loose fine-sediment deposition but little aquatic vegetation) that become exposed during low flow. Bottom substrate generally of silt, clay, and organic matter.	6.8
Flowing channels	Relatively fast flowing riffles, runs, glides, thalwegs, and side channels. Includes sandy depositional bars such as point bars, side channels, and multi-thread channels in deltas with current. Bottom substrate generally of sand, gravel, cobble, boulder, or bedrock.	14.2
Depositional backwaters, pools, and side channels	Depositional areas along channel margins where widening occurs with standing or slow-moving water. Includes pools, side channels, meander cutoffs, and tributary mouths with standing or slow moving water that are connected to the main channel. May include mudflats during low flow. Bottom substrate of silt, clay, and organic matter.	2.2
Bars	Low-lying depositional features surrounded by water with various communities of forbs, shrubs, and wetland. Above water during normal flow but lower than the floodplain or island elevations. Mainly found in Morrow Lake Delta.	0.3
Emergent wetlands	Frequently inundated fens, marshes, wet meadow near the channel margin and in the floodplain with herbaceous vegetation.	6.6
Islands	Generally forested area surrounded by water and at similar elevations as the floodplain and forested scrub-shrub wetlands.	0.9
Oxbows, meander cutoffs, ponds	Features with standing water in overbank areas related to abandoned channels, meander cutoffs, oxbows, spring-fed ponds, flood chutes, and back swamps. Connected	0.7

Major Habitat Type	Definition and Examples	Percentage of Total Area
	to the main channel only during floods.	
Forested scrub-shrub wetlands	Overbank areas with deciduous forest and scrub-shrub wetlands subject to seasonal or temporary flooding. Sometimes saturated. Includes ephemeral pools.	39.9

Table 13 – Resource Categories Used in Development of the Kalamazoo River NEBA

Resource Category	Notable Species in the Kalamazoo River Impounded Waters and Associated Deltas
Plants	Water-lilies, arrowhead, pondweeds, wild celery, coontail, watermilfoil
Mammals	Muskrat, raccoon
Birds	Trumpeter swan, ducks, geese, great blue heron, spotted sandpipers, tree swallows, cedar waxwings, red-winged blackbirds, yellow warblers
Amphibians/Reptiles	Snapping, eastern spiny softshell, and common map turtles; northern water snakes; green frogs
Fish	Smallmouth bass, bluegill, channel catfish, shiners, northern pike
Invertebrates	Mussels, crayfish

The overall risk of exposure/impact to a particular resource from each of the five possible pathways was considered a function of the magnitude of impacts and the recovery of that resource to baseline/reference levels (Table 14). The magnitude of impacts varied from low to very high (Table 15), whereas the length of recovery varied from very short to long (Table 16). Because multiple pathways may simultaneously impact a single resource, the relative risk ranking of the overall impact of specific oil recovery actions focused on the most detrimental pathway mechanism(s).

Table 14 – Potential Exposure/Impact Pathways

Exposure Pathway	Example	Source	Pathway

			Code
Aqueous Exposure	Inhalation/ingestion of whole oil droplets, dissolved components, or suspended particulates (e.g., flakes) in the water column	Globules, sheens, dissolved oil, flakes	1
Sediment Exposure	Exposure to oil globules in sediments or residual oil in sediments	Oiled sediments, macro/micro pore oil	2
Physical Trauma	Trampling, mechanical impact from equipment, impacts from removal	Mechanical stressors	3
Physical Oiling/Smothering	Direct contact with oil/oil residues	Submerged globules, surface mats, patties on sediments	4
Indirect	Food web, ingestion of contaminated food, increased water column turbidity, increased noise, impacts associated with boat traffic, sediment smothering, bank erosion, loss/displacement of prey	Contaminated food, habitat disturbance	5
Exposure does not occur			NA

Table 15 – Anticipated Degree of Resource Impact Relative to Baseline/Reference

Categories	Estimated Level of Impact Relative to Baseline/Reference (%)	Score
Low	0-10	D
Moderate	10-30	C
High	30-60	B
Very High	> 60	A

Table 16 – Anticipated Length of Recovery Relative to Baseline/Reference

Categories	Estimated Length of Recovery (Years)	Score
Very short-term	< 1 year	4
Short-term	1-3	3
Intermediate-term	3-7	2
Long-term	> 7; does not recover	1

The final color-coded matrix of relative risk rankings ranged from low impact (4D), with a resource impact of less than 10% estimated level of impact relative to baseline or reference and less than one year for recovery, to very high impact (1A), with a resource impact of greater than 60% and greater than seven years for recovery (Table 17). The rankings were based on the current knowledge of the degree of oiling starting in the fall of 2011 after two seasons of intensive recovery actions.

Table 17 – Relative Risk Ranking Matrix for the Kalamazoo River

		Length of Recovery			
		Very Short-Term	**Short-Term**	**Intermediate-Term**	**Long-Term**
Degree of Resource Impact	Low	4D	3D	2D	1D
	Moderate	4C	3C	2C	1C
	High	4B	3B	2B	1B
	Very High	4A	3A	2A	1A

Supporting information used in the relative risk rankings included, but was not limited to: acute aquatic toxicity results and sediment characteristics from stream bottom samples collected in winter 2012 from the Enbridge oil-affected reach of the Kalamazoo River, a literature review of potential ecological effects resulting from sediment agitation, and an analysis of turbidity data associated with sediment agitation in the Kalamazoo River during the Line 6B response (AR-0963). The FOSC and operations staff considered these relative risk rankings in the NEBA to evaluate tactical approaches for residual submerged oil removal and to determine cleanup endpoints.

The relative risk rankings also included several major assumptions, summarized below.

1. The rankings were based on the current knowledge of the degree of oiling starting in the fall of 2011, after two seasons of intensive recovery actions.
2. Submerged oil recovery activities were expected to be targeted to selected areas of the river with residual submerged oil going forward rather than covering the entire 40 mi of affected river in an upstream to downstream approach, as was done in 2010 to 2011.
3. The magnitude of the impacts of recovery actions was based on an anticipated footprint for a tactical area being about 0.1 to five acres.
4. Rankings were conservative in that they were based on the aquatic organism most likely to be affected by the greatest magnitude and length of recovery.
5. Recovery times for aquatic organisms would start after the end of the 2012 submerged oil recovery season (assuming recovery would occur).
6. Recovery times for aquatic organisms that depend on aquatic vegetation were assumed to be at least as long as the recovery times for the plant community.
7. Toxicity effects from the oil on aquatic organisms were assumed to be less than or the same as physical effects from turbidity.
8. The remaining Line 6B oil appears to be weathered, and toxicity may decrease to some extent over time.

The relative risk-ranking matrix was applied to each resource category and recovery option combination for individual habitat types. Table 18 shows an excerpt for two habitat types of the much larger table for depositional areas of the river where remaining submerged oil had accumulated.

Table 18 – Summary of NEBA Relative Risk Matrix for Kalamazoo River

Habitats	Resource Category	Recovery Actions							
		Monitored Natural Attenuation	Enhanced Deposition	Agitation Toolbox	Dredging/Vacuum Truck	Dewater/Excavate	Sweep/Push	Scraping	Sheen Collection
Impounded Waters and Associated Deltas	Plants	4D	3B	3B	3B	NA	3B	4C	4D
	Mammals	4D	4D	4D	4D	NA	4D	4D	4D
	Birds	4D	4D	4D	4D	NA	4D	4D	4D
	Amphibians/reptiles	3C	2B	2B	2B	NA	2B	4C	4D
	Fish	3C	2B	2B	2B	NA	2B	4D	4D

Habitats	Resource Category	Recovery Actions							
		Monitored Natural Attenuation	Enhanced Deposition	Agitation Toolbox	Dredging/Vacuum Truck	Dewater/Excavate	Sweep/Push	Scraping	Sheen Collection
	Invertebrates	3C	2B	2B	2B	NA	2B	4C	4D
Depositional Backwaters, Pools, and Side Channels	Plants	4D	3A	3A	3A	3A	3A	3C	4D
	Mammals	4D	3D	3D	3D	3D	3D	4D	4D
	Birds	4D	4D	4D	4D	4D	4D	4D	4D
	Amphibians/reptiles	3C	2B	2B	2B	2B	2B	3C	3D
	Fish	3C	3B	3B	3B	3B	3B	4C	4D
	Invertebrates	3C	3A	3A	3A	3A	3A	3C	4D

In general, the NEBA found that organisms have shorter recovery times and a lower degree of impact for sheen collection, natural attenuation, and scraping than for enhanced deposition, agitation toolbox, dredging, dewater/excavate, and sweep and push techniques. However, some risk of toxicity to benthic receptors was assumed possible in moderate and heavy oiled areas. Because of their depositional setting and accumulation of residual submerged oil, impounded waters and depositional backwater habitats would likely have higher risk associated with natural attenuation because high rates of sedimentation, burial over time, and existing biological conditions likely retard natural attenuation in these areas. It was assumed that residual submerged oil remobilized from upstream, either through resuspension during floods or incomplete recovery actions, would likely accumulate in these depositional settings. These areas continued to have oil manifestation on the water surface throughout 2012 and 2013. Comparatively, the Kalamazoo River has thick beds of native aquatic and emergent vegetation in a variety of relatively slow and fast water habitats. Most of the physical removal techniques result in removal or disturbance of the vegetation. The recovery time and degree of resource impacts for amphibians/reptiles, fish, and invertebrates in many habitats are the same or worse than for aquatic vegetation since the plants provide food and shelter for many species.

Once completed, the NEBA relative risk rankings were overlaid with submerged oil tactical areas by individuals from the SSCG and operations staff. These tactical areas were areas of the

Kalamazoo River that had moderate or heavy submerged oil poling results. The shape, size, and number of tactical areas changed after each poling reassessment to reflect changes in the areal extent of moderate and heavy poling results. The NEBA application was first performed with May 2012 tactical areas (143 areas) based on the Fall 2011 Poling Reassessment and winter 2011/2012 observations and assessments. The NEBA tactical area application was revisited in June 2012 after the tactical areas were expanded from 143 areas to approximately 240 areas after incorporation of the spring 2012 poling reassessment results. In December 2012, the June 2012 NEBA tactical area recommendations were revisited again at the three major impounded reaches of the Kalamazoo River affected by residual submerged oil in light of additional monitoring information or data collected during the intervening time period.

Monitored natural attenuation and sheen collection were repeatedly recommended for most tactical areas, but there were some important exceptions:

- For designated sediment traps, the NEBA recommended to follow the sediment trap monitoring and maintenance plan and consider dredging if oil accumulations exceeded the trigger for recovery action. The NEBA conceptual document assumed that sediment traps would require repeated active submerged oil recovery, possibly every six months or after a major flood.
- Agitation toolbox techniques were not recommended for recovery given the uncertainty associated with potential physical and chemical effects from disturbance of the stream bottom.
- For areas where moderate and heavy poling results stayed the same or increased, the NEBA suggested increased monitoring frequency and continued evaluation for possible future recovery. A number of tactical areas in or near flowing channel habitats had noticeably more moderate and heavy poling results in spring 2012, as compared to fall 2011.
- Because of the high likelihood that the submerged oil and oiled sediment in flowing channel habitats could migrate during high-flow events, the NEBA recommended dredging, hydrovac, or hand scraping while water levels were low. These included tactical areas in the three impounded reaches, where repeated poling results and modeling indicated accumulations of oil and oiled sediment during low flow periods and potential resuspension and transport during high flow events.
- For the Morrow Lake Delta and Fan, the NEBA recommendation was to subdivide the area into smaller tactical areas for further evaluation and application of the NEBA.

The recommendations over time for ten tactical areas in the vicinity of the Mill Ponds along the Kalamazoo River near Battle Creek, Michigan give an idea of how the recommendations changed over time (Table 19). Five of the tactical areas showed increases in moderate and heavy poling results over time, with December 2012 recommendations of consider recovery. Four of the tactical areas remained the same or had less oil over time. The remaining tactical area included a sediment trap that showed increases in moderate and heavy poling results in 2012.

Table 19 – NEBA/Tactical Area Recommendations, Mill Ponds (May – July, 2012)

Tactical Area Name	Size (acres)	May 2012 Recommendation	June 2012 Recommendation	December 2012 Recommendation
SO 14.81	2.28	Sheen collection/monitored natural attenuation, enhanced deposition	Follow sediment trap monitoring/maintenance plan and consider recovery using dredging/hydrovac (easy road access), especially in oiled area downstream of trap	Follow sediment trap monitoring/maintenance plan and consider recovery using dredging/hydrovac (easy road access), especially in oiled area downstream of trap
SO 14.83	0.06	Sheen collection/monitored natural attenuation	Sheen collection/monitored natural attenuation	Sheen collection/monitored natural attenuation
SO 15.10	2.92	Sheen collection/monitored natural attenuation	Sheen collection, increase monitoring frequency, continue to evaluate for possible future recovery actions	Sheen collection, increase monitoring frequency, continue to evaluate for possible future recovery actions, avoid areas with regrowth of beneficial aquatic vegetation
SO 15.23	10.28	Sheen collection/monitored natural attenuation	Sheen collection, increased monitoring frequency, natural attenuation, possibly no other recovery because of high quality vegetation	Sheen collection, increased monitoring frequency, natural attenuation, possibly no other recovery because of high quality vegetation
SO 15.25	0.04	NA	Sheen collection/monitored natural attenuation	Sheen collection/monitored natural attenuation
SO 15.35	0.33	Sheen collection/monitored natural attenuation	Sheen collection/monitored natural attenuation	Sheen collection/monitored natural attenuation
SO 15.45	0.52	Sheen collection/monitored natural attenuation	No active recovery necessary	No active recovery necessary

Tactical Area Name	Size (acres)	May 2012 Recommendation	June 2012 Recommendation	December 2012 Recommendation
SO 15.56 LDB	0.36	NA	Sheen collection/monitored natural attenuation	Sheen collection, increased monitoring frequency, continue to evaluate for possible future recovery
SO 15.56 RDB	5.21	Sheen collection/monitored natural attenuation	Sheen collection, increased monitoring frequency, continue to evaluate for possible future recovery	Sheen collection, increased monitoring frequency, continue to evaluate for possible future recovery, protect remaining high quality vegetation
SO 15.65	2.04	NA	Sheen collection, increased monitoring frequency, continue to evaluate for possible future recovery (dredging/hydrovac)	Sheen collection, increased monitoring frequency, continue to evaluate for possible future recovery (dredging/hydrovac)

The December 2012 update of the NEBA tactical area application and integration for Ceresco Impoundment, Mill Ponds, and Morrow Lake Delta resulted in very few changes to NEBA tactical area recommendations from May and June 2012. For tactical areas with similar or increases in moderate and heavy poling results, recommendations were to increase monitoring frequency and continue to evaluate for possible recovery. Similar to the May and June 2012 recommendations, and in the absence of conclusive acute toxicity results for submerged oil, December 2012 recommendations for the FOSC to evaluate active recovery for some tactical areas in the impoundments were made because of persistent ongoing oil manifestation on the water surface. There was expected to likely be some additional ecological benefit and no net ecological harm from active recovery in these areas because of the longevity of the oil manifestation beyond what was originally expected and the ability to start the time of ecological recovery for these areas sooner than later.

8.6. Quantification of Residual Submerged Line 6B Oil

Two areas of practical application depend on either relative or absolute estimates of the quantity of residual Line 6B oil in the affected area:

1. First, the FOSC required periodic reporting on the progress of oil removal, and an estimate of the residual oil volume was one measure of progress that was useful as an independent cross-check on that progress.

2. The quantification of residual oil was also a factor considered in determining what, if any, additional response actions were prudent. These cleanup options were weighed through the NEBA. The environmental cost benefit analysis for some options depended on the amount of residual oil present and what fraction of that amount a given option was expected to recover or sequester over time.

As a result of these considerations, the FOSC directed Enbridge to estimate the quantity of residual submerged oil resulting from the Line 6B discharge.

8.6.1. Oil Quantification Study (Spring 2011)

In July 2011, the FOSC directed Enbridge to quantify the submerged oil identified during the Spring 2011 Reassessment (poling survey). In response to the FOSC's directive, Enbridge analyzed sediment chemistry data and physical properties measured from sediment samples of varied types collected for disparate purposes and developed a calculation model. The analytical model for oil volume quantification required five input variables: lateral extent of area containing submerged oil, thickness of oil-containing sediment, dry bulk density of sediment, oil density, and oil concentration in sediment.

Enbridge included areas where poling observations indicated submerged oil was present and estimated the thickness of oil-containing sediment for 54 selected bed cores by visual observations of oil sheen/globules. Dry bulk density of surficial bed-sediment samples was measured for a subset of 2011 core locations, and density of oil was assumed to be that of similarly diluted, fresh Cold Lake bitumen. TPH concentrations, not Line 6B oil concentration, were the basis for estimating oil mass for each of three areal strata corresponding to heavy, moderate, and light submerged oil. Sources of data included bed cores collected in 2011 at 90 sites for three separate studies, cores collected in 2010 at 357 poling points, and additional cores collected for studies of risk from direct-contact recreation exposure and other small studies.

There were significant flaws in the Enbridge estimation, a few of which are summarized below.

- Enbridge assumed zero submerged oil in areas where sediment agitation (poling) had not produced visible indications on the water surface. A temperature threshold for valid poling was not yet in use at this time, so cold temperature, variable illumination, variable water-surface conditions, subsurface interference, and/or other factors may have invalidated this assumption.
- Sampling designs were not well documented; samples came from different years, with an intervening flood flow; and sampling was not randomized. Sampled locations, therefore,

were not independent or representative. Without randomization, a biased sample was likely under the circumstances described.

Accordingly, Enbridge's resulting estimates of residual oil volume were inaccurate and could not be relied upon because the methods used by Enbridge were not scientifically based.

8.6.2. Oil Quantification Study (Fall 2011)

In December 2011, the FOSC's approval of Enbridge's Consolidated Work Plan for 2012 included use of a scientifically based model to quantify the submerged oil for the entire affected water way corresponding to MP 0 through Morrow Dam. The model was to be used with data from sediment cores collected after the completion of 2011 oil recovery activities (Enbridge, 2011b), thus distinguishing the estimate from the spring 2011 study.

The analytical model for fall 2011 quantification used the same five input variables as for the spring 2011 study, and additionally included the option to account for concentrations of residual hydrocarbons and oil from historical sources that may be present in sampled bed sediment and contributing to measured levels of TPH.

The Consolidated Work Plan allowed for the quantification model to be flexible to allow quantification of the oil volume within specific geomorphic strata, river reaches, or broader river areas, and its output would include evaluations of uncertainty. The study included data from 109 cores collected from depositional areas where poling observations indicated submerged oil was present, and additional cores from outside the affected area as background samples. Enbridge logged lithology and estimated the thickness of oil-containing sediment for cores by visual observations of oil sheen/globules, including observation of most cores under UV illumination. Dry bulk density of surficial bed-sediment samples was measured for fall 2011 core locations, and density of oil was assumed to be that of similarly diluted, fresh Cold Lake bitumen. Each distinct sediment layer in a core was subsampled and submitted for the analytical laboratory determination of TPH concentration (not Line 6B oil concentration). TPH results for 472 samples from the affected area and 114 samples from four background areas were the basis for estimating oil mass for each of three areal strata corresponding to heavy, moderate, and light submerged oil. Data analysis focused on graphical and statistical comparisons between the two sample groups: background and affected areas.

Like the spring 2011 estimation, there were significant flaws in the Enbridge estimation, a few of which are summarized below.

- Enbridge assumed zero submerged oil in areas where sediment agitation (poling) had produced no visible indications on the water surface. The 60 °F temperature threshold for valid poling was not yet in use at this time, so cold temperature, variable illumination, variable water-surface conditions, subsurface interference, and/or other factors may have invalidated this assumption.
- Stratified sampling design did not include a randomization component. Sampled core locations included only nine cores from areas of light submerged oil. Without randomization, a biased sample was quite likely under the circumstances described.

- Laboratory analysis was limited to TPH constituents, parent PAHs, and metals. Alkylated PAHs and biomarkers were not analyzed, so forensic chemistry data analysis to determine the Line 6B oil concentration was not used. Historical oil sources and natural background may have masked the Line 6B oil in the results from many samples.
- Statistical tests for differences between groups used an approach where results less than the highest detection limit were recensored as less than that limit. This causes loss of information.

Although the documentation of methods and data for the fall 2011 study was superior to that for the spring 2011 study, the results provided in Enbridge's February 8, 2012 report did not gain EPA approval.

8.6.3. Oil Quantification Study (2012)

As a result of EPA's disagreement with Enbridge's estimation of the amount of residual Line 6B oil, the FOSC directed the SSCG to evaluate viable analytical approaches to quantify the amount of submerged oil in the Kalamazoo River sediments that was attributable to the Enbridge Line 6B release and to recommend the best approach to accomplish this goal. Individual members of the SSCG provided their recommendations for the 2012 study to quantify submerged oil residual volume, and these were conveyed to the FOSC (cover letter dated August 8, 2012) on topics including:

- stratification of affected area for sampling to quantify Line 6B residual oil;
- characterization of background hydrocarbons;
- spatial distribution of sample locations;
- methods for collecting sample cores; and
- methods for processing sample cores and core-layer samples.

The FOSC directed Enbridge to complete the submerged oil quantification (November 20, 2012 directive) using the SSCG recommendations. Attachments to the directive letter conveyed the SSCG recommendations (EPA, 2012), along with results of a pilot test of the submerged oil quantification methods for core sampling and analysis.

Enbridge documented its coring, core description and sampling, analytical laboratory methods, and data analysis methods in its March 21, 2013 report (Enbridge, 2013i). The study included data from 102 cores collected from the sampling strata, including those where Spring 2012 Reassessment poling observations indicated submerged oil was present and also those with no visual evidence of submerged oil presence. Enbridge logged lithology for 99 cores and collected subsamples either based on visual observations of oil sheen/globules (either by UV or visible illumination) or, in cases where no visible evidence was seen, collected a sample from the top one inch of the core and subsequent stratigraphic layers were each sampled separately. Dry bulk density of surficial bed-sediment samples was measured for a geomorphically well-distributed subset of 37 core locations.

The study approach taken in 2012 differed substantively from previous studies. The probabilistic sampling design was based on stratified random sampling, where sampling strata consisted of combinations of geomorphic setting and submerged oil (poling) categories mapped using a reproducible inverse-distance weighted method. Core collection and processing were prescribed to minimize loss of floccules at the water-sediment interface, and cold storage was used to better preserve the surficial layer of sediment intact. A poling observation was made at the time of core collection, quality control replicate cores were collected, and subsamples of selected core intervals were prepared for laboratory analysis using the incremental sampling method (systematic-random selection) to composite aliquots. However, most core subsamples collected were not analyzed for sediment chemistry. Analytical results for alkylated PAHs and biomarkers were further evaluated using forensic techniques.

For estimating the Line 6B oil concentration in each analyzed sample, EPA and Enbridge followed different procedures based on different assumptions and understandings of the forensic chemical fingerprints of Line 6B oil and the natural and historical background hydrocarbons present in most samples. EPA and Enbridge also developed distinct methods for the spreadsheet calculators used to compute the residual oil volume. EPA averaged concentrations for each vertical interval across each sampling stratum, whereas Enbridge calculated an average concentration for the part of each core that it considered to lie within the Line 6B-affected thickness. For this purpose, Enbridge considered a Line 6B oil concentration less than their forensic limit of detectability to be a non-occurrence of Line 6B oil. By substitution with zero as the oil concentration for a core with no detected Line 6B oil, despite not having analyzed the vertical intervals of the core and the use of varying limits of detectability, the substituted zero value introduced a negative bias into both the mean depth of impact and the mean concentration for each sampling stratum that contained such non-detections.

EPA and Enbridge also used very different approaches for estimation of uncertainty in the estimated volume of residual oil. EPA estimated the uncertainty in each contributing factor and combined these sources to calculate an overall uncertainty.

In a May 8, 2013 letter to Enbridge, the FOSC determined that Enbridge's March 21, 2013 report on submerged oil quantification contained invalid conclusions and significantly underestimated the volume of Line 6B residual submerged oil in the river. The deficiencies in the Enbridge report relating to environmental chemistry concerns and forensic analysis to distinguish Line 6B oil from residual background hydrocarbons originating from other sources were detailed in Attachment 1 to the FOSC's May 8, 2013 letter to Enbridge. Attachment 2 of that same letter contains a technical memo explaining details of how EPA applied the required methodology to derive its estimated volume of Line 6B residual submerged oil.

In November 2015 the FOSC shared with Enbridge the report with additional information that became available that indicated a reevaluation of EPA's May 8, 2013 estimate of Line 6B residual submerged oil volume was appropriate. The additional information included: oil fingerprinting analyses of additional sediment core samples; revisions to EPA guidance on the handling of nondetect sample results; and reevaluation of Line 6B oil fingerprinting methodology by EPA chemists. This revision was prompted in large part to an EPA policy change on the handling of non-detect values in sample results and their weight in overall volume estimation. Further review of Enbridge methodology and EPA methodology also led to lowering of EPA's estimate of the uncertainty of results, as described in EPA's November report to Enbridge and attachments (EPA, 2015).

8.6.4. Conclusions

By applying the required methodology, EPA provides residual Line 6B oil volumes that range from lower-bound to upper-bound estimates, with uncertainties specific to those estimates creating a range for each. The upper-bound estimate is 86,000 gallons with an uncertainty range from 35,000 to 181,000 gallons, and the lower-bound estimate is 49,000 gallons with an uncertainty range from 19,000 to 101,000 gallons of oil. Given the available data, EPA concludes that the best estimate of residual Line 6B oil volume lies in the range of 49,000 to 86,000 gallons; it may be as little as 19,000 gallons or as much as 181,000 gallons. It is important to note that these volume estimates represent EPA's best estimate of the residual Line 6B oil present in the Kalamazoo River at the time that the investigative sediment cores were collected (July to November 2012). Subsequent occurrences in the river (e.g., sediment dredging, spontaneous sheening, biodegradation) would remove a portion of the submerged oil estimated to be present in July to November 2012. Some of the disagreement between EPA and Enbridge regarding the residual Line 6B oil volume is based upon alternative chemical interpretive methods to identify Line 6B oil in Kalamazoo River sediments; this topic is discussed in Section 8.7.

8.7. Chemistry

8.7.1. Limitations of Conventional Methods

The original analytical methods used (Table 20) by Enbridge at the start of the response consisted of conventional analytical method for measuring petroleum hydrocarbons and constituents of petroleum products. These analytical methods were selected to obtain analytical data that could be compared to Michigan Part 201 Groundwater and Soil Cleanup Criteria and Screening Criteria.

Table 20 – Analytical Methods Originally Used

Target Analytes	Analytical Method
Volatile organic compounds (VOCs)	SW-846 Method 8260B
Semi-volatile organic compounds (SVOCs)	SW-846 Method 8270A
TPH as DRO, ORO and GRO.	SW-846 Method 8015B

These methods yielded results that were initially helpful in determining the location and partial concentration of petroleum hydrocarbons resulting from the Line 6B discharge. As the diluent from the DilBit volatilized and/or otherwise weathered, the lighter-end constituents could not be used to identify Line 6B DilBit because the residual longer-chain hydrocarbons were outside of the method quantification boundaries. TPH analyses using these methods were also subject to interference from anthropogenic and naturally occurring sources of hydrocarbons.

8.7.2. Fingerprinting

The sampling and analysis plan was updated in 2012 to provide more definitive testing methods for the measurement of Line 6B oil. These methods included the following and were collectively referred to as fingerprinting and included:

- PAHs and sulfur heterocyclic compounds, including alkyl homologues, by gas chromatography with low resolution mass spectrometry using selected ion monitoring (GC/MS-SIM);
- saturated hydrocarbons by gas chromatography with flame ionization detection (GC/FID);
- total extractable hydrocarbons (TEH) representing the total aromatic and aliphatic hydrocarbon content of sample extracts after silica gel cleanup and analysis by GC/FID; and
- petroleum biomarkers by GC/MS-SIM.

In general, these methods were more sensitive and provided the information necessary to differentiate Line 6B oil from residual hydrocarbons, both anthropogenic and naturally occurring.

8.7.3. Mixing Models

The fingerprinting methods provided the raw information to differentiate Line 6B oil from background hydrocarbons. EPA and Enbridge chemists collaborated to develop a method for interpreting the raw data. The chemists looked at the distribution of PAHs and alkyl PAHs in the Line 6B oil and in the sediments. The PAHs and alkyl PAHs were useful in differentiating naturally occurring constituents from Line 6B oil but were not able to provide the definitive differentiation necessary for the identification and quantitation of Line 6B oil from other petroleum sources. As a result, the chemists evaluated numerous petroleum biomarkers and ratios of different petroleum biomarkers to differentiate Line 6B oil from other petroleum sources. The EPA chemists settled upon the ratio of C(28) 20S-triaromatic steroid to hopane as the best mechanism to differentiate and quantitate Line 6B oil in the presence of residual hydrocarbons.

The chemists oversaw a range finding study and method detection limit study to determine the detectability of Line 6B oil in Kalamazoo River sediments. Because Line 6B oil exists in the presence of residual hydrocarbons, mathematical mixing models were developed to measure the concentration of Line 6B oil present in the mixture. The mixing models were based upon Line 6B oil ratio responses and changes in the ratio responses when background ratio responses were added.

In combination, the evaluation of the PAH and alkyl PAH patterns, the evaluation of biomarker ratios, and the mixing model constituted the analytical portion of multiple lines of evidence supporting the presence and concentration of Line 6B oil in the sediments of the Kalamazoo River and Morrow Lake.

8.8. Core Logging Procedures

Enbridge collected and logged soil and sediment cores for many operational activities throughout the response. The sampling method was selected for widespread use because it yielded relatively undisturbed samples of either sediment or soil. The procedure also allowed for vertical profiling and enabled observation of sediment or soil composition, as well as discrete changes in observable oil and other visually distinguishable characteristics.

Core samples were prepared for logging by draining residual water from the core sample sleeve, cutting the core sleeve along its length, and splitting the core sample in half. Classifications made during core logging were performed in accordance with both the Unified Soil Classification System and USDA soil classification systems at each depth interval recorded.

Each core was typically subdivided into lithologic layers. Supplemental observations recorded for each separate layer during logging included the number and size of any oil particles and the presence or absence of oil sheen on core surfaces. Oil/sheen tests using the jar/shake method under visible light were also performed on each lithologic layer logged.

The core logging process also included observation of the layers using a high-intensity, LED UV light source beginning in mid-2011, and then was further supplemented by high-resolution photography of cores under fixed-source visible and UV light implemented in late 2011. The UV light sources used for both the handheld and fixed source applications consisted of Low Voltage Ultra Violet (LVUV) fluorescing spotlights manufactured by Vertek, with a peak UV-A wavelength of 365 nanometers (nm). Under UV spotlight illumination, known particles of Enbridge Line 6B oil typically showed a visible fluorescence response in the yellow-orange range (i.e., approximately 460 nm). Observations of UV fluorescence with the handheld source were recorded as the core samples were logged. As the high-resolution photography required some post-processing of the resultant images, use of the handheld UV light inspection of core samples was continued in conjunction with the enhanced photographic method to obtain real-time UV fluorescence observations during logging.

Following completion of the above core logging activities, subsamples of individual lithologic layers or core depth intervals were collected for analytical purposes. The identifying sample name, sample depth interval, and sample date and time of core subsamples were recorded during logging. The procedures used for core subsample collection varied and are described in separate subsections of this report.

Observations from the core logging events were further processed by entering this information in electronic spreadsheet format in project databases. GIS files were created from the electronic format logging data, combined with sample geographic coordinate data, and used extensively for geomorphic mapping and other project applications.

8.9. Limited Toxicity Evaluation – Acute Exposure

Enbridge performed a limited evaluation of the toxicity of Line 6B oil. The toxicity testing consisted of exposing *Chironomus dilutus* and *Hyalella azteca* organisms to Line 6B oil and observing the organisms' survival rate over a 10-day period, considered to represent an acute-exposure. Nutrients (goldfish food, yeast, trout, and cerophyl) were added to the test vessels daily during the 10-day test period, and temperature and light were controlled to mimic river conditions.

Most *Chironomus dilutus* and *Hyalella azteca* had greater than 70% survival rates at the conclusion of the 10-day test period. Results of the toxicity evaluation performed by Enbridge were documented in a report entitled *Chironomus dilutus and Hyalella azteca 10-day Whole Sediment Toxicity Testing Results, Kalamazoo River Sediment Sampling Line 6B Oil Spill,* *Marshall, Michigan* (GLEC, June 2012).

8.10. Agitation Effects Study

As part of the Line 6B oil recovery operations in 2010 and 2011, Enbridge agitated sediments of the affected Kalamazoo River using agitation toolbox techniques in an attempt to recover submerged oil. This primarily consisted of sediment agitation followed by surface recovery of liberated/floating oil/sheen. Enbridge used this recovery method in many depositional areas of the affected Kalamazoo River.

However, a study of the efficacy and the potential adverse ecological effects of using agitation techniques had, prior to the study described herein, not been performed. The potential adverse effects considered herein include, but are not necessarily limited to: increased mobility of the liberated/suspended oil; increased toxicity to aquatic organisms from residual oil suspended in the water column and transported downstream; increased turbidity and downstream burial and smothering of sand, silt, and clay associated with the agitation process; and increased erodibility of residual oil and sediment on the streambed following agitation.

In March 2012, a member of the SSCG recommended[2] to the FOSC implementation of a tiered approach to evaluating the potential ecological effects of sediment agitation techniques including:

- Tier I: Review of existing project data (chemistry, toxicity, etc.) and other published literature regarding the potential effects of sediment agitation, and
- Tier II: Perform bench-scale and/or field applications of agitation techniques while simultaneously collecting water quality measurements and collecting samples for analyses.

Results of the Tier I evaluation performed by EPA were presented to the FOSC at an SSCG meeting. As part of the Tier II activities, potential effects of agitation were evaluated by performing controlled in-situ studies of agitated oil-containing sediment.

The SSCG also recommended[3] a toxicological assessment on the potential effects of Line 6B oil and/or sediment containing Line 6B oil suspended during sediment agitation efforts.

The purpose of the Agitation Effects Study (AES) described herein was to evaluate the potential consequences of using sediment agitation for future recovery of Line 6B residual submerged oil in the Kalamazoo River, including Morrow Lake (including its delta and fan).

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[2] *SSC Recommendations to the FOSC, Evaluating the Efficacy and Potential Ecological Effects of In-Situ Sediment Agitation (Summer 2012)*, Enbridge Line 6B MP 608 Marshall, MI Pipeline Release, August 8, 2012. This document is referenced as the "Work Plan" herein.

[3] *Recommendation to the FOSC, Toxicological Assessment of the Effects of Residual Weathered Oil and Increased Suspended Solids Resulting from Sediment Agitation*, Enbridge Line 6B MP 608 Marshall, MI Pipeline Release, August 8, 2012. This document is referenced as the "Dose Response Study" herein.

Sediment size distribution analysis was conducted with a Laser In-Situ Scanning and Transmissometry (LISST) 100X (Type C) particle analyzer (Sequoia Scientific Inc., Seattle, Washington) during the AES. LISST is an optical device that measures the size and volume of particles in a sample based on the physical properties of light as it is scattered by the particles. The purpose of these measurements made during the AES was to understand the type and density of various sediment particle sizes that become suspended during agitation efforts.

Using a mass balance of the Line 6B residual oil within the mesocosm before and after the sediment agitation test, recovery efficiencies (relative to pre-agitation conditions) of less than 1% were documented. The mass of Line 6B oil contained in the sheen and oil globules that rose to the water surface, where they were recovered, represented 0.705%, 0.756% and 0.358% of the total pre-agitation Line 6B residual oil mass contained in the sediment at MP 37.45 (Delta Z), MP 37.4 (Delta EE) and MP 5.55N, respectively. In the three locations were the agitation test samples (sheen/globules, sediment and water) were analyzed, over 99% of the residual Line 6B oil mass was sorbed to the sediment both before and after agitation. Thus, it was concluded that concentrations of Line 6B residual oil in sediments were not reduced by sediment agitation. Line 6B residual oil concentrations in sediments became elevated during sediment agitation.

Given that additional Line 6B residual oil was not added to the studies, it appears that the formation of OPA and/or oil/sediment redistribution/homogenization during sediment agitation may homogenize or otherwise redistribute Line 6B residual oil within the sediments.

A summary of key conclusions based on the information referenced herein and contained in ancillary reports is presented below.

- Ancillary studies performed on Line 6B residual oil found that OPA is likely formed when energy (i.e., water from sediment agitation) is imparted to Line 6B residual oil and fine sediments.
- Ancillary studies confirmed that only an estimated 25% of Line 6B residual oil is readily biodegradable (in optimum conditions that are not likely prevalent in the Kalamazoo River).
- An estimated 75% of Line 6B residual oil incorporated into OPA from further agitation work would likely become more mobile through natural dispersion and would not be readily biodegradable.

In a letter to the FOSC dated August 8, 2012, the SSCG recommended that Enbridge perform a set of toxicological experiments that would facilitate collection of data to directly address the toxicological effects of increased turbidity and Line 6B oil on aquatic resources. However, Enbridge declined to perform the recommended procedure that would have developed dose-response curves for the effects of turbidity and Line 6B submerged oil on aquatic resources. These data are necessary to evaluate the potential effects of Line 6B oil recovery via sediment agitation on aquatic organisms.

8.11. Assessment Procedures - Statistics

The technical information obtained during the response spanned the range from visual observations and semi-quantitative data (e.g., categorized poling data), through model-simulated values or validated (but sometimes imprecise) laboratory results, to precise measures of river parameters (e.g., temperature, turbidity, flow) and GPS-derived coordinates. Because the FOSC often used a weight of evidence from multiple lines approach to decision making for operational responses, scientific information had to be reviewed for reliability, replicability, and objectivity. Quality control information often was collected, but in some cases the analysis of the data quality was delayed awaiting availability of trained technical personnel.

Validation of laboratory determinations was routinely performed, but for many other sources of data, work plans often were unclear about how data quality would be assured. Over the extended period of response, numerous and varying approaches were taken to quality assurance. Although the overall QA project plan (Enbridge, 2010) provided guiding principles and specified details for producing verified data from sample results from analytical laboratories, it lacked specifics covering the wide range of information being collected.

8.11.1. Statistical Evaluation of the HDM

Statistical measures of the agreement of the HDM model simulated values with calibration targets for a baseline simulation were limited to daily stage and stream flow values at USGS stream gages, Enbridge staff gages, and vertically averaged current velocity at dozens of points using ADCP methods at selected river cross sections. For the July 2010 floodplain-model calibration only, simulated river stages also were compared with heights of oil marks (Enbridge, 2012e). Acceptance criteria for the model calibration initially were lacking, but the FOSC directed Enbridge to propose criteria and compare the criteria with the level of agreement achieved between simulated and observed values. The directed comparison implies a statistical analysis. Descriptive statistics were used to summarize calibration comparisons to stream flow and water stage targets, including mean-absolute and root-mean-square errors and, for stream flow rate and velocity only. Uncertainty of the measured target values was not considered during model evaluation. The ongoing HDM will include statistically based comparisons to check the calibration of the new models, including root-mean-square errors, percentage of simulated values within the 95% confidence interval of the corresponding target values, or other literature-recommended measures.

8.11.2. Sediment Core Locations

Prior to 2012, the sampling plans for collection of sediment cores can be statistically described as directed sampling because core locations were selected by field practitioners and were not a probability sample drawn from locations in the affected area. The use of mapped geomorphic settings to stratify the affected area for the purpose of developing an objective, balanced sampling design is appropriate and was foreseen in the CWP.

When the variable being studied is residual Line 6B oil concentration, an effective stratified sampling design would exhibit concentration variation between strata that accounts for a significant fraction of the total variance. Two mapped variables, fluvial geomorphic setting and submerged-oil poling observation class, that each were correlated with differences in fall 2011 oil concentration (TPH; EPA, 2012, App. 1) were used in combination for the stratified-random sampling design used for the 2012 submerged oil quantification study. Results (EPA, 2013) showed larger within-stratum variance in oil concentration than expected, but concentrations differed significantly among strata, presumably because residual spilled oil, as well as background hydrocarbons, had associated with fine sediment and organic matter by physical and chemical processes, and these settle out in specific fluvial settings but remain in suspended transport through other settings.

8.11.3. Nondectections and Summary Statistics

Most environmental monitoring study results include left-censored data (i.e., less-than values or non-detections). Although simple substitution with a fraction of the detection limit is commonly performed in some scientific studies, such fabrication is known to introduce invasive patterns into a data set, often leading to inaccurate descriptions and erroneous interpretations. In the December 2011 CWP (Enbridge, 2011b, p. 51), the FOSC directed Enbridge to use a statistically based method to approximate the quantity of residual oil and a confidence interval for its estimate.

In its May 2012 submerged oil quantification report submittal, Enbridge (2012b) used statistical graphs to summarize concentrations of TPH in sediment. Rank-based statistical graphs and tests were used to compare groups and test for differences between group medians because non-normal sampling distributions and censored data were present. However, much information is lost in comparison to using methods that are intended for use with data sets containing multiple detection levels. As a result, subsequent statistical evaluations used regression on order statistics, which are suitable for data containing censored values at multiple detection levels. Similarly, EPA used another, nonparametric method (Kaplan-Meier) that is widely used for values censored at multiple detection levels.

8.12. Ebullition and Barometric Pressure

In fall 2010, there was anecdotal evidence that manifestation of submerged oil on the water surface increased when there was a drop in barometric pressure. Although this phenomenon was observed on several occasions, it was not explored until late 2012. As a result, the FOSC directed SSCG to evaluate the observed response.

8.12.1. Ebullition

The movement of gases from the sediment to the water column is referred to as ebullition. When the gasses that are trapped or have formed through biogenic production move to the water column, they can facilitate the transport of collocated contaminants in the sediment. Under anaerobic conditions, carbon dioxide and methane are formed by bacterial and microbial activity and, when the concentration of the produced gases exceeds the saturation point of the pore spaces in the sediment, bubbles form. Because of the irregular shape of these bubbles in the sediment column, contaminants in the sediment can attach to the large surface area of the bubble and are transported to the water column, where they can become dissolved in the water column or released to the water/air interface. As a result of ebullition, submerged oil can manifest on surface water.

Ebullition can be a more active contaminant transport mechanism during periods of increased temperatures, when bacterial and microbial activity is present and produced gas pressure in sediment increases. Similarly, ebullition is also increased when there is a drop in pressure overlying the sediment. The drop in pressure on the sediment may be due to a drop in the depth of the water column and/or a drop in atmospheric pressure.

EPA evaluated limited data sets of temperature, barometric pressure, and observances of submerged oil manifestation on surface water to explore predictive capabilities for submerged oil manifestation based upon temperature and drops in barometric pressure. The preliminary evaluation of the data indicated that further evaluation would be required prior to developing the use of barometric pressure as a predictive indicator of sheen events requiring maintenance responses.

8.13. OPA

For over 25 years, laboratory and field studies have demonstrated that both mineral fines and organic particles can stabilize oil droplets in water. These particles are often referred to as OPA and can be formed when these materials are present together with sufficient mixing energy, which can include natural forces such as wave action or turbulent river current. OPA occurrence has been demonstrated at numerous oil spills around the world. The FOSC contacted an expert in this field, Dr. Kenneth Lee of the Centre for Offshore Oil, Gas and Energy Research (COOGER), Fisheries and Oceans Canada to conduct the following analyses:

- determine whether Kalamazoo River sediments from the Spill Response Area contain OPA,
- determine if Line 6B oil will form OPA in the presence of Kalamazoo River sediments when agitated under laboratory conditions,
- conduct 3D fluorescence spectra analysis of the source oil and Kalamazoo River sediments so that optimal excitation/emission wavelengths of UV light can be established, and
- verify the effectiveness of UV fluorescence as a means of identifying residual Line 6B oil during spill response operations.

8.13.1. OPA in Kalamazoo River Sediment

Kalamazoo River sediment samples were examined and photographed under UV epifluorescence and transmitted white light at the COOGER Dartmouth, Nova Scotia laboratory. The results indicated that 11 of 41 sediment samples contained evidence of oil fluorescence, most commonly as dispersed oil droplets. One sample was found to contain readily identifiable OPA.

8.13.2. OPA Creation with Line 6B Oil and Kalamazoo River Sediment

When sediments from the Kalamazoo River were mixed with distilled water and Line 6B source oil, numerous examples of OPA were readily identified by UV-epifluorescence microscopy. When the same sample was examined again after two days without agitation, OPA was still present and larger OPA were abundant, possibly the result of coalescence of OPA particles. These observations demonstrate that OPA was readily formed from site-specific oil and sediments.

8.13.3. Optimal Excitation/Emission Spectra

COOGER conducted 3D fluorescence analysis of the Line 6B oil and selected sediment samples, which identified optimal excitation wavelengths from 300 to 350 nm and optimal emission wavelengths from 400 to 550 nm. The determination of optimal excitation/emission wavelengths was critical for this response, since UV-excited fluorescence was employed as a tool for visualizing Line 6B oil both in the laboratory studies as well as in field investigations.

8.13.4. UV Effectiveness in Visualizing Line 6B Oil

In the process of examining the 3D fluorescence data from Kalamazoo River sediment samples, COOGER identified an inverse relationship between the level of TPH, as measured by chemical analysis, and the fluorescence intensity of a solvent extract of the same sample. The expected result is for the fluorescence intensity to increase as the concentration of oil increases. This result suggested that there was some process of fluorescence quenching associated with some compound or class of compounds that was present in the solvent extract of the Kalamazoo River sediment sample. This suggestion was confirmed by COOGER when the extracts were separated into two fractions: aromatics and saturates (smaller molecules) and asphaltenes and resins (larger molecules). Fluorescence intensity increased dramatically in the asphaltene and resin fraction, demonstrating that molecules present in the oil itself were quenching oil fluorescence.

These results suggest that field-screening methods relying on UV fluorescence could under-estimate the oil that is present, or even generate false negative conclusions (i.e., a conclusion that oil is absent when it is actually present).

8.14. FOSC Commentary on the Effectiveness of Science in Supporting the Response

Within a few weeks of the discharge, conventional recovery strategies had led to recovery of nearly all floating oil in the river. Characterization of the extent of submerged oil impact and development of strategies for its recovery soon became dominant operational priorities. Operational detection and recovery of submerged oil within an expansive and diverse riverine development had to be guided by science. Moreover, multiple lines of multidisciplinary scientific evidence were required to guide these efforts. Their respective importance is described in the ensuing paragraphs:

<u>Geomorphology</u>

- Understanding the erosion, transport, and deposition of fine-grained soft sediment was key to monitoring and mapping submerged oil. OPA behavior and depositional tendencies can be preferentially tied to this stratum to guide a model of where deposition should occur.

<u>Temperature Effects</u>

- The studies performed under this task did not attempt to address of the factors that might be involved in the release of submerged oil from agitated sediments. However, the studies clearly demonstrated the importance of coordinating temperature measurements with subsequent poling activities. As a result, the FOSC directed the development and implementation of a Temperature Measurement SOP, requiring systematic temperature measurements using reliable instruments to accompany future poling measurements. Furthermore, the FOSC determined that poling results would not be accepted when the accompanying water/sediment temperatures were less than 60 ^{0}F. As a direct consequence, temperature restrictions on the acceptability of poling results placed seasonal constraints on the use of poling to document the presence of submerged oil.

Biodegradation Analysis

- Overall, it was concluded that the residual oil within the Kalamazoo River from the Enbridge Oil Spill has the potential to undergo further degradation. However, the absolute amount of oil which may be removed via degradation is limited to roughly 25% of the mass. Additional degradation may occur but would be expected to occur over an extended time period (many years), in part due to the high levels of asphaltenes (the tar-like long chain hydrocarbons) present in the Line 6B oil.

- Field conditions where the residual oil exists will impact the rate and extent of residual oil degradation. While nutrient levels may not be limiting to in-situ biodegradation, low oxygen conditions, which typically exist in subsurface sediments, will limit the rate of biodegradation. Attempts to address submerged oil by enhanced biodegradation did not appear to be a viable oil recovery option at this site. If physical removal of oiled sediments is not performed, it is likely that any residual submerged Line 6B oil will remain associated with Kalamazoo River sediments for many years.

- Lastly, the physical nature of the residual oil will affect the degradation of residual oil. It has been noted that the residual oil in Kalamazoo river sediments often exists in discrete masses or globules. This physical behavior limits the surface area upon which oil biodegrading organisms can access the oil, which may limit the extent of Line 6B oil biodegradation within the river. If the residual oil is located in sediments that are subject to erosion and transport, it is likely that the oil globules will be broken up and dispersed as smaller oil particles.

Hydrodynamic Modeling

- Even though there were major data gaps and the models had to be constructed quickly, there were many applications of the preliminary model results for flow, water levels, velocity, and shear stress. The models helped to identify areas of the river that likely remained depositional during low and high flows, and areas of the river that likely changed from depositional to erosion when flows increased. Close coordination and communication among the science, operations, modeling, and GIS staff made it possible to get timely and operationally effective turnaround between asking questions and model results for containment and recovery strategies

- Relatively recent developments in remote sensing made it possible to construct rather detailed complex hydrodynamic models for a large reach of the river relatively quickly, which proved to be useful for response operations. High-resolution LIDAR data were available for constructing detailed topography of the floodplain. High-resolution survey-grade GPS was used to collect the geospatial coordinates of thousands of poling assessment points, which could be used for bathymetry. Strong on-site GIS capabilities made it possible to construct relatively detailed and complex maps on a daily basis. Acoustic/sonar methods, combined with survey-grade GPS, can be used to construct bathymetric maps that are easily stitched together with the LIDAR based topographic maps for a complete picture of floodplain and channel elevations.

NEBA

- Additional ecological information obtained in the future is not expected to substantially change the NEBA relative risk matrices or their integration with the tactical areas. However, additional information will be useful for ecological risk assessments conducted over longer time scales. The integration of the NEBA relative risk matrices with tactical areas and oil spill response was a useful tool, bringing together the known hydrogeomorphic and ecological science associated with the spill along with other sources of information for the FOSC and operations staff to decide on the best recovery option for areas with remaining submerged oil.

Quantification of Residual Submerged Line 6B Oil

- The quantification of residual submerged Line 6B oil was accomplished after overcoming several technical obstacles. State-of-the-art oil analytical chemistry was needed to develop methods for identifying Line 6B oil in river sediments that contain widespread residual hydrocarbons derived from heavy oil. Statistical methods were employed to incorporate site knowledge (geomorphic units) into a sediment sampling program that allowed for efficient use of analytical data that would provide an estimate of residual submerged Line 6B oil volume, as well as an uncertainty associated with that estimate.

AES

- More studies are necessary to determine the effectiveness and the effects of agitation in different physical settings. Pending that work, use of agitation strategies for submerged oil recovery should be considered only for discrete target areas where complete containment is possible and where careful NEBAs justify the approach. Examples of such targeted areas that are off river or out of direct river currents and can be completely contained with full silt curtains are backwaters, side channels, oxbows, impounded areas where containment can be strictly controlled to minimize downstream migration, or areas behind constructed weir dams where containment can control both surface and subsurface transport of oil and suspended sediment.

Assessment Procedures - Statistics

- Replicability is a fundamental characteristic of sound science; sample selection, subsampling, compositing, and data analysis should receive scrutiny to ensure that documented, repeatable, and defensible methods are used, objectivity is maximized, and that inappropriate assumptions and arbitrariness are avoided or minimized.

- Choice of statistical methods should be based on careful consideration of sampling method, analysis method, and characteristics of resulting data such as percentage of non-detections and number of detection levels. During emergency responses, the typically hurried environment in which data are sometimes interpreted before time is invested in appropriate data analysis can lead to poor estimates, incorrect statistical results, and erroneous interpretations.

- Standard statistical methods are available to measure the probability distribution for summary statistics and thereby to derive estimates of uncertainty. These methods should be applied to characterize inaccuracies of individual methods, and where appropriate, propagation of uncertainty should be modeled using established procedures that vary for different forms of variable combinations (e.g., additive versus multiplicative).

OPA

- The work performed by COOGER was invaluable to our understanding of the behavior of Line 6B oil in the Spill Response Area:
    - It demonstrated that the discharge of DilBit into a Midwestern river resulted in the formation of OPA, a common feature of oil spills throughout the world. It is likely that the sequence of events leading to submergence of Line 6B was the initial evaporation of diluent, leading to an increase in weathered oil density and viscosity, followed by formation of OPA with mineral fines leading to particle densities greater than 1.0.
    - It demonstrated that compounds present in this DilBit interfere with UV screening methods. Caution must be urged when using these methods.
    - It demonstrated that the physical characteristics of OPA will be important in accurately defining the nature of the particles that should be incorporated into sediment transport models.

<u>Core Logging</u>

- Observations of sediment cores using the high-intensity UV light source (e.g., handheld) and the high-resolution fixed source visible light and UV photography may have been a more effective screening tool for sediment samples if implemented from the beginning of the project. Over the course of the project, the fluorescence response of the remaining Line 6B oil in sediment samples appears to have diminished due to probable strong adherence to interfering sediment particles and decreasing oil particle size resulting from natural and oil recovery-induced agitation. UV inspection of core samples appears to have retained its effectiveness in overbank settings due to a tendency towards larger size original oil accumulations in the overbank soil materials and less subsequent disturbance.

- Even with improved logging and screening methods, the amount of Line 6B oil present in sediment core samples is difficult to assess from visual observations under visible or UV light. In most cases, visual observations appeared to underestimate the amount of oil present in the sediments relative to subsequent releases observed during oil recovery agitation or indicated by oil quantification chemical analyses. Comparison of accurate analytical chemical data to the visual observations at an earlier stage in the project would have been helpful as a check on the reliability of the visual observations.

- Logging personnel must be aware of potential non-oil sources of fluorescence in core samples when using UV screening methods. Common non-oil sources can include plant or wood debris and natural minerals (e.g., aragonite). Careful, real-time inspection of apparent fluorescent sources during logging must be employed.

- Entry of logging data into electronic format for use in GIS files is recommended to increase overall usefulness of the data for mapping and other purposes.

- On large projects involving large sample volumes and multiple logging teams, cross-training of logging personnel is strongly recommended to ensure accurate and consistent core logging records.

9. Logistics

Effective logistics support was critical to ensuring that all resources required to conduct response operations were delivered. Enbridge, being the major provider of response resources, including personnel, equipment, and materials, implemented logistics in a manner independent of EPA via its normal corporate procurement mechanisms. EPA's and Enbridge's respective logistics organizations each provided their own logistics personnel to support their respective organizations. All necessary coordination between them was achieved by structured organizational interaction within the overall ICS.

This section provides a roughly chronological discussion of important logistics considerations and events that EPA, Enbridge, and other early UC entities were confronted with during successive phases of the response.

9.1. Incident Command Posts (ICP)

For roughly the first 36 hours of the response (July 26 to 27, 2010), UC coordination and operations were conducted at the Enbridge field office on Leggitt Road in Marshall. The first government-managed ICP was located at the Calhoun County EOC in Battle Creek Michigan beginning on July 27, 2010. As EPA personnel arrived at this first ICP, the EPA Region 5 Mobile Command Post and vital Internet connectivity for EPA personnel were established. Several hours later, the Mobile Command Vehicle/Sprinter arrived and was deployed to a location closer to the Line 6B Source Area.

Figure 101 – Walters Elementary School ICP

Once the temporary mobile command unit was functioning, EPA logistics personnel began looking for a more suitable location within Marshall, Michigan to establish an ICP. Proximity to the Source Area near Marshall, larger-size footprint to handle all multi-agency and Enbridge needs, parking, and Internet and cell phone connectivity were major criteria for a new facility. With state congressional assistance, the Calhoun Intermediate School District and the Marshall Public Schools were contacted and agreed to assist. On July 28, 2010 a new interim ICP was established at Walters Elementary School (Figure 101). When establishing the ICP at Walters Elementary School, it was known that this ICP location would only be temporary given that children would return to school within a few weeks (mid-August 2010).

9.1.1. Walters Elementary School ICP (July-Early August, 2010)

Use of the school as a temporary ICP began on July 28, 2010. Certain parts of the school were unavailable for use because preparations were being made for the upcoming school year. Other parts of the school had designated uses, and meeting rooms could be reserved.

Figure 102 – UC Meeting at the Walters ICP

Because a UC (Figure 102) had been established, it was important for the EPA, other governmental agencies, and Enbridge to be located in close proximity to each other to facilitate functioning of the UC. EPA and other governmental agencies occupied a portion of the school, while Enbridge occupied another segregated and isolated part of the school. This proximity with segregation principle was maintained throughout the response duration to underscore for the public and other stakeholders that while coordinating, EPA and Enbridge maintained separation appropriate to their enforcement relationship.

By the afternoon of July 28, 2010, initial work began at the school to establish the ICP. Classrooms were set up for various ICS Sections (i.e., Planning, Logistics, etc.), and the cafeteria was set up as a large meeting/conference room. At the request of the Michigan Governor, the State of Michigan's Department of Technology, Management and Budget (DTMB) performed a reconnaissance of Walters Elementary School, and it was determined that additional Internet infrastructure was necessary to establish adequate Internet connectivity and to support other communications. In addition, it was determined that security and controlled access to the ICP would be required. DTMB provided equipment necessary to make identification badges for response personnel and initial security personnel at the ICP.

9.1.1.1. Food and Lodging

Simultaneously with establishing an ICP, it became evident that the response was going to include a large work force, including EPA personnel and other government responders. EPA logistics personnel immediately began securing local lodging, which had begun to fill up rapidly due to the increasing size of the response organization. This function soon transitioned to the EPA Region 5 EOC, in conjunction with its management and in coordination with all other EPA regions to fill over 100 EPA staff positions. The search for lodging was rapidly expanded to other nearby communities and cities up to 50 miles away.

Field personnel assigned to oversee Enbridge contractor response work were responsible for managing their own food needs. The Salvation Army provided meals for several hundred governmental agency staff at the ICP for a brief time. Subsequently, local vendors were contacted and began providing meals for sale at the ICP. However, this presented challenges because the vendors would provide service for a few hours at a time and were not able to fully support non-stop operations with constantly rotating personnel. As a result, this option was also short-lived and superseded by response personnel making their own arrangements.

9.1.1.2. Resources for Air Operations

Due to the expansive nature of the discharge, it became immediately apparent that aerial reconnaissance (Figure 103) of the response area would be required. Logistics personnel made arrangements to conduct air operations from Brooks Field, which was near Walters Elementary School, in Marshall, Michigan.

Figure 103 – Helicopter Used to Perform Aerial Reconnaissance (8/25/2010)

9.1.1.3. Supplies, Equipment & Services

The EPA Region 5 logistics go-kits bought to the site in an EPA equipment trailer provided basic office supplies and equipment to establish an initial ICP (Figure 104). EPA provided purchase cards to logistics personnel as needed and also increased credit card limits to allow for adequate provisioning to support the response. Procurement options used by logistics staff for buying supplies were: agency purchase cards, blanket purchase orders, and contracts implemented by Level II and III EPA Contracting Officers.

Figure 104 – Identification Badge Creation at Walters ICP (8/8/2010)

Equipment orders and tracking were maintained by using ICS Form 213RR, personal property custody cards, property stickers for sensitive items, and T-Cards for personnel tracking. Office supplies were kept in boxes at the Logistics Section room and were distributed upon request.

Local sheriff and MSP staff provided security presence at the ICP. Private security firms were later hired to augment security and to limit access at the ICP. EPA personnel worked with Enbridge security staff to establish traffic control plans. One-way traffic patterns were established when possible to increase driving safety.

9.1.1.4. Information Technology (IT) and Communications

It was obvious from the start of the response that the GIS Unit of the Planning Section would require a substantial number of servers and electronic storage due to the amount of data being managed.

Throughout the first few days of the response, the number of connections to the Internet was limited to preserve capacity for critical operations. Wireless access was provided in the IC office, PIO, UC, General Staff, Planning Section and cafeteria commons area. Satellite communications were largely ineffective due to the large data transmission requirements, particularly for GIS and transmission of environmental data.

Three NAS devices of eight terabytes each were used to backup data on a daily basis. One NAS was dedicated to GIS, a second NAS was dedicated to the rest of general and command staff, and the third unit was set up to back up each NAS every other day.

The State of Michigan was able to provide valuable Information Technology (IT) assistance because it had prearranged on-call emergency response IT providers. Communications within the ICP and to the Region 5 EOC were typically by VoIP telephones or cell phones. In addition, they provided two-way 800 MHz radios for use by all key entities within the ICS early in the response.

These MSP radios used a network that reached the entire state and were, therefore, available for all areas spanned by the response. The county sheriff provided a unique frequency for use by the response organization. Two-way radios were issued to key members of the UC and others directed by the FOSC. The DTMB provided computer servers, ID badging equipment, and radio equipment for long distance communications (repeaters) and facilitated interactions with local cell providers to increase their local capacity to better support the response efforts.

9.1.2. Pratt Avenue ICP

As previously mentioned, Walters Elementary School could only be used as the ICP for a limited duration due to the impending start of the 2010 public school year. As a result, the FOSC directed personnel to secure an alternate location at which to relocate the ICP. The search for an alternate facility started on August 5, 2010.

An idle manufacturing/warehousing facility located at 1601 Pratt Avenue, just a few miles south of Walters Elementary School, was selected as a site for the next ICP.

Figure 105 – Pratt Avenue ICP, Trailers for Meetings and Regulatory Work Space

Enbridge contracted for and provided the facility. EPA and other government agencies occupied the external portions of the warehouse, where Enbridge provided basic accommodations consisting of trailers (up to 13 at the height of operations – Figure 105), office furnishings (desks, chairs, etc.) and sanitary facilities for governmental UC operations. Enbridge occupied the interior portions of the facility, including most of the warehouse and the administrative offices.

9.1.2.1. Supplies, Equipment & Services

Requests for supplies, equipment, and non-facility services operated in the same fashion as conducted at the Walters Elementary ICP.

Enbridge provided for facility security, utilities, management, maintenance, and repair. As a result, coordination between EPA Logistics and Enbridge Logistics was necessary to ensure adequate operating facilities for governmental agencies.

9.1.2.2. Facilities

The DTMB began withdrawing its staff and support when the move to the Pratt ICP began. As DTMB withdrew, Enbridge began providing EPA logistical support for purchases, facilities, and communications. The move from the Walters Elementary School to the 1601 Pratt Avenue location occurred over the last two weeks of August 2010.

During the first several months of occupancy at the Pratt ICP, the parking space was inadequate until Enbridge expanded its parking lot further south. Enbridge maintained the grounds and structure complex at the Pratt ICP, except for EPA servers, IT hardware, and other equipment owned by EPA. Enbridge also provided phones and Internet service.

9.1.3. Preston Drive ICP (October 2012 to September 2014)

Enbridge's lease of the Pratt Avenue facility expired in October 2012. At that time, EPA and MDEQ staff, contractor personnel, and response administrative personnel (ICP staff) occupied a vacant former day care facility located at 13444 Preston Drive in Marshall, Michigan, where EPA and MDEQ remained collocated for the remainder of EPA's involvement as the FOSC on the response. Enbridge elected to house its project management and administrative staff on Kalamazoo Avenue in Marshall, where it had previously established a community outreach center.

9.2. FOSC Commentary on the Effectiveness of the Logistics Section

All major construction project operations are made possible by logistics. In emergency responses to disasters, there is always great pressure to conduct operations even before logistical systems can be mobilized and stood up to enable those operations. Logistics personnel must be mobilized first. They are necessary to establish the facilities for administration of the response organization and to house, feed, and supply the operations elements of the organizations. This principle not only applies to the RP, but also to those governmental agencies responsible for directing and overseeing response actions.

Early establishment of a functional ICP is always paramount in importance for effective response to major incidents because it is essential to the effective formation and development of ICS/UC. In the case of this response, once all parties were able to be functionally collocated and supported with IT and telecommunications, the launch of the ICS planning cycle became enabled, resulting in effective operational planning and progressive development of the organization. Ideally, contingency plans should universally contemplate this fact and contain scripts for ICP location and setup. Alternatively, EPA and industry response organizations should build, train, and exercise powerful and empowered logistics personnel for deployment at the earliest juncture following an incident. Logistics teams, private or governmental, must have experienced procurement personnel. For EPA, it is critical to have a Level III Contract Officer (CO) at the beginning of the incident since this level provides a CO with special warrant authority for purchases. If possible, a Level III CO should accompany the Logistics Section Chief to the incident as part of the Finance Section, especially if special contracts/procurements for IT, telecommunications, courier services, aircraft rental, and other reoccurring funding are expected. Also, a Level III CO with a credit card will have a single purchase limit of $500,000 and monthly limit of $500,000. A Level III CO can only use a credit card when he is deployed to an emergency response site or an Incident of National Significance. Convenience checks are limited to $5,000.

While similar procurement authority must exist in each organization's EOC (usually back in their respective off-site headquarters), real-time field situational urgency demands that a doctrine for enabled field logistics teams must be maintained. This model has long been practiced by military and disaster response organizations worldwide.

EPA was extremely fortunate to have the State of Michigan's DTMB provide network connections at Walters Elementary School. The same held true at the Pratt Avenue Site, where Enbridge technicians installed IT and telecommunication hookups.

In anticipation of future responses, EPA must establish mechanisms for IT and Telecommunication contractor set-up services.

10. Finance

10.1. Response Funding

Funding for oil spill responses that affect navigable waterways is provided by the Oil Spill Liability Trust Fund (OSLTF), which is maintained by USCG. The OPA/1990 authorizes the use of the OSLTF for oil spill response. FOSCs can access the OSLTF by calling the National Pollution Funds Center (NPFC) or by using the Ceiling and Number Assignment Processing System (CANAPS). EPA and USCG have predetermined FOSCs who can access the fund at any time up to an initial limit. For EPA, the initial limit is normally $50,000. At the time of this discharge, however, strain on the fund had been caused by the massive mobilization to direct and oversee response work on the BP Gulf Oil Spill, leading to a reduction of that initial limit to $25,000.

On July 26, 2010 EPA Region 5 personnel requested funding from the OSLTF using CANAPS. A Federal Pollution Number (FPN) was established for the response, an initial ceiling of $25,000 was provided, and a case manager was assigned. Once the first responding OSCs were on-scene, it quickly became apparent that the $25,000 ceiling would be quickly exhausted, and a ceiling increase to $300,000 was requested from the NPFC. As the response continued, the ceiling was raised several times at the request of the FOSC. By the end of the second week of the response, the FPN ceiling was at $11 million.

Due to the size of the spill and the funding requests through the NPFC, the regional manager and case manager from the NPFC visited the response to meet with EPA staff and gain a direct sense of how long the response would continue and for what the requested funds were being used. FPN ceilings over $250,000 require an OPA/1990 90 Project Plan (OPA/1990 90 PP) to be written explaining the response situation, what the funds will be used for, and estimated future costs. On August 6, 2010 the first OPA/1990 90 PP for the response was submitted to the NPFC with an estimated expenditure of $27 million. The daily burn rate was estimated at $470,000 per day. Updated OPA/1990 90 PPs were submitted as appropriate when funding requests exceeded the initial cost estimates. As of September 2014, the latest OPA/1990 90 PP for the response requested the ceiling be raised to $69,250,000.

10.2. Limitations

EPA has an Interagency Agreement (IAG) with the USCG NPFC authorizing funding from the OSLTF. Since this single response was estimated to exceed the funding EPA had from the IAG at the time, the Region 5 Office coordinated with HQ to request an amendment to the IAG to increase funding. This was especially important as EPA was providing ongoing assistance to the

BP Gulf Oil Spill response. The regional oil response funding was quickly depleted; however, EPA HQ requested unused oil response funding from the other EPA regions to fund the response. As Fiscal Year 2010 ended and Fiscal Year 2011 began, funding was added to the IAG to specifically ensure that Region 5 would have sufficient funds to continue this response.

10.3. RP Liability, Role, and Funding

Enbridge, as the RP, has the responsibility to pay for cleanup costs and to reimburse the OSLTF. As EPA used funds, the costs were tracked and billed to the NPFC. The NPFC reimbursed EPA and then sent a bill for the response costs to the RP. Typically, this process would happen at the end of a response, but due to the large amount of funds being spent, reimbursement requests were generated by EPA on a monthly basis to the NPFC.

In addition to reimbursing the OSLTF, the RP funded its own contractors, set up a fund for state agencies to draw from, and directly paid several contractors.

10.4. Contractors/PRFAS

In the initial days and weeks of the response, using funding from the OSLTF, EPA mobilized three ERRS contractors to provide containment and clean up assistance. In addition, EPA issued a contract to a response organization with expertise in boom deployment strategies to assist with the response. EPA also mobilized START contractors for technical assistance in relation to the spill.

In addition to private contractors, EPA provided funding for other federal agencies that it requested to assist in responding to the oil release, most notably USFWS, NOAA, USGS, and USACE. These agencies either had their own requirements to meet for oil spill responses or were mobilized at the request of the FOSC. Because these agencies could not access the OSLTF directly, EPA ensured the agencies received appropriate levels of funding through the use of Pollution Removal Funding Authorizations (PRFAs). Costs were incurred pursuant to these other federal agencies and were billed against the established project FPN. EPA reviewed and approved bills against the PRFA, and the USCG paid the bills directly to the agencies.

10.5. Cost Tracking

It was extremely important for EPA to monitor costs to not only avoid unauthorized obligations (exceeding the FPN ceiling), but to continually evaluate overall project cost effectiveness. While EPA was responsible for accounting for the total FPN ceiling, it was also necessary that EPA monitored the individual ceilings for its three ERRS contractors, one START contractor, multiple agency PRFAs, USCG personnel, several private contractors, and EPA direct and indirect costs. All of these individual ceilings could not be exceeded. In order to accomplish this, a Finance Section Chief was assigned to the response in the field who had access to the region’s accounting system. EPA contractors submitted expenditures on a daily basis, and costs were reviewed by an OSC for approval. OSCs were assigned to manage individual contractors and approve resources. Individual contract ceiling increases were made within a five-day projection fund depletion. As PRFAs were issued, the ceilings were subtracted from the FPN project fund availability ceiling.

A daily cost spreadsheet was compiled and distributed to EPA management and the USCG NPFC to support funding requests. During the response, no ceiling was exceeded of both the total FPN and individual categorical ceilings.

10.6. Cost Control

Utilizing the ICS helped EPA control costs. Resources had to be requested, and approving authority was limited to a small number of field personnel. Personnel with higher purchase card limits made site purchases to limit the number of personnel making purchases. A contracting officer was brought to the response site to assist with contracting requirements.

10.7. FOSC Commentary on the Effectiveness of Finance

The scale, complexity, and duration of this response were unprecedented within the context of the EPA/USCG NPFC relationship and working history. As such, there were challenges that needed to be overcome and lessons learned. The major ones resulted in the following recommendations:

1. The limits for the IAG with USCG should have been increased at the end of Fiscal Year 2010 in order to maintain enough liquidity for unstrained funding for the Enbridge Line 6B Oil Spill, BP Gulf Oil Spill, and oil projects and oil spills nationwide. EPA and USCG should modify the IAG to include automatic triggers for ceiling expansions to ensure such liquidity following the occurrence of major discharges.

2. EPA regions should be given the flexibility to establish spill-specific IAGs with USCG for major spills (Enbridge, SONS). This would have the same effect as (1) above, by not causing an unanticipated compression of liquidity on the IAG.

3. RPs should be required to set up a special account. EPA has this option under CERCLA. In this era of shrinking resources and limited budget, the special account will provide funding for oversight for federal and state responders.

4. USCG and EPA should try to avoid making institutional and administrative accounting process changes during major spills (e.g., changes to the invoice review and approval process). In the present case, such changes resulted in slowdowns in invoice approval by NPFC, leading to ceiling increase slowdowns and frequent crises on response resource funding and planning for this project and others.

5. While the PRFA mechanism was suggested as a way to fund Environment Canada personnel who helped create a SCAT program to assist EPA in quickly training teams to do this work, USCG NPFC was unable to process this. Ultimately, this was resolved when Enbridge agreed to pay the costs directly to Environment Canada. Going forward, EPA and USCG should establish a mechanism by which these resources can be made available during a major response. Equipment sharing plans exist (CANUSCENT), but the financial mechanics of the resource sharing have not been established. In addition to the SCAT service it provided, Environment Canada could also have provided TAGA-like air monitoring and sampling unit deployment when EPA's units were tied up with the BP

Gulf Oil Spill response. These resources were not mobilized due in part to the uncertainty of how to fund their deployment.

11. Communications

When the Enbridge Line 6B discharge occurred, public and media awareness of oil spills was already heightened because of the BP Gulf Oil Spill that had occurred four months earlier. Although there were many differences (e.g., fresh water versus salt water, inland versus marine) between the Line 6B and BP spills, citizens and the media were making comparisons of these two disasters and speculating on how the Line 6B discharge would be addressed. This heightened awareness and sensitivity to oil spills further fortified the rapid and continuous involvement of the EPA HQ PIO in communicating with the public and the media. In addition to responding to media calls through the IC, media briefing sessions occurred twice daily at the beginning of the response to afford the media opportunities to ask questions of the responding agencies.

11.1. Community Meetings

The first community meeting was held on August 2, 2010, less than one week after the Line 6B spill was reported. An estimated 700 residents attended the meeting, where senior personnel from EPA, MDEQ, USFWS, MDCH, MDNR, CCHD and PHMSA provided updates and were available to answer questions. Enbridge also had a presence at the open house and interacted with the citizens. A second community meeting was held in Battle Creek approximately one week later on August 10, 2010 and followed the same general format as the first meeting.

In September 2010, the agencies again sponsored a meeting, this time in Galesburg, a community located approximately 40 mi from the spill site and close to Morrow Lake. Because the township was so far from the spill, residents there were not as concerned about the potential immediate health impacts. They were more concerned about the potential for long-term environmental damage to the nearby Morrow Lake and how the spill was going to affect their ability to use the lake. The lake is major recreation site for boating and fishing.

In 2011, EPA held a similar set of meeting in the same communities. Large community meetings have not been held since 2011.

In addition to the community meetings, EPA engaged in other community outreach activities, many of them coordinated through the Public Information/Community Involvement Office under the FOSC General Command.

11.2. Back to School

Aware that many of the initial events had taken place during summer break, EPA was sensitive to the fact that schoolchildren would be returning to a landscape that had been dramatically altered. EPA met with Marshall school administration and representatives from the grade, middle, and high schools. EPA suggested that the schools hold meetings to explain to the pupils what had occurred in July and what the agencies were doing to make sure that they were safe despite the spill. The schools accepted the offer and had presentations for the pupils. Two area colleges also requested that EPA make presentations to their communities.

11.3. Other Outreach

In addition to initiating meetings, EPA participated in meetings organized by local groups, such as the PlayCare Day Care and a Village of Ceresco community organization. At those meetings, EPA was among the invited responders who were present to address concerns of the residents. Some other outreach activities included:

- Response-specific website: While websites are matter-of-fact for remedial sites, this was initially thought to be a removal. The enormity of the spill and its consequences were not immediately apparent, but the website was very useful in keeping the community informed of activities on nearly a daily basis.
- Community involvement plan: Area residents were interviewed to ascertain their preferences for how and when to receive information about the response activities.
- Fact sheets: EPA created 18 fact sheets for the response, with five translated into Spanish after EPA determined that there is a significant Hispanic community in the Battle Creek area. The fact sheets were distributed at public locations throughout the community (e.g., convenience stores, libraries, gasoline stations, local advertiser newspapers, and posted on the EPA website).
- County fair: Based on suggestions in the community involvement plan, EPA staffed a booth at the Calhoun County Fair in 2011 and 2012. More than 200 visitors stopped to talk about the response activities each year and hundreds more picked up information.
- Visitor center: In 2013, the FOSC increased community access to EPA by establishing a visitor center at EPA's ICP whereby citizens could obtain information about response activities.
- Tribal outreach: In November 2013, EPA held an open house for tribal members of the Nottawaseppi Huron Band of Indians at the reservation's stakeholder group.

The MAC stakeholder group served as a conduit for regular information flow between residents and the FOSC and MDEQ. Outreach material produced by EPA was vetted through the MAC to ensure that the residents' concerns were addressed.

11.4. FOSC Commentary on the Effectiveness of Communications

Early in the response, EPA relied upon a communications team headed by a senior federal official to support the FOSC by managing external communications with the public, media, and congressional entities. This team also served as the briefing conduit between the FOSC and senior EPA officials in Washington. This model enabled the FOSC to direct response actions and manage the ICS coordination function with local, state, tribal, and natural resource trustee interest.

During the ensuing years of the response, EPA maintained a practice of engagement with local and state agencies through UC/MAC. This allowed external communications to be effectively planned and implemented according to an ongoing sense of the needs of the constituencies of these respective organizations.

EPA used Community Involvement Coordinators (CICs) to assist the FOSC with messaging and outreach and to be a link with regional staff to facilitate the formation and approval of fact sheets for distribution. At times when these CICs were not physically on site, delays were noted in the efficiency of finalizing these community updates.

12. Recommendations

12.1. Means to Prevent a Recurrence of the Discharge or Release

PHMSA is the primary regulatory agency for pipeline operation and maintenance. As such, EPA will not speculate on the administration or amendments to those regulations in this report.

12.2. Means to Improve Response Actions

EPA considers the response to this incident highly successful. An unprecedented amount of the oil has been recovered. EPA made adjustments during the life of the response to not only have a successful response to floating oil, but to develop and implement new strategies to recover the spilled material when conditions changed. The multitude of lessons learned on the recovery of suspended and submerged oil made during the four years of this response can guide future spills of similar material. The FOSC has made a concerted effort to document and share these findings.

For the response community, early detection of and planning for suspended and submerged oil, OPAs, and getting ahead of the scientific process to understand each specific spill will be key in effecting a successful response.

12.3. Proposals for Changes in Regulations and Response Plans

EPA and USCG in Region 5 have made a shift in focus of area planning exercises and trainings to look more closely at heavy and sinking oils and the resultant new techniques required to effect a successful cleanup. Pipelines and other industries have been heavily recruited to participate in these drills and support this planning work. A greater focus on having industry in general become more proficient and on par with the government agencies in using and working in the ICS structure is also underway. This effort will lead to more effective communication and management of major spills in the future.

Stronger outreach and development of awareness of pipeline presence and operations would undoubtedly help to reduce impact to public health and the environment following pipeline releases. This can also be accomplished through broader participation by local agencies in the area planning process and will likely assist in first line, local agency discovery, reporting, and response and ultimately help contain spills earlier.

While PHMSA regulates pipelines and their facility response plans, EPA and USCG are the federal agencies responsible for managing responses to pipeline discharges. As such, EPA and USCG must continue to encourage and foster the involvement of PHMSA in the crucial area planning process where response agencies are continually updating plans, conducting drills and exercises, and striving to understand how pipelines work.

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