Enbridge Energy, Limited Partnership
1601 Pratt Avenue
Marshall, Michigan 49068

December 21, 2011

Mr. Ralph Dollhopf
Federal On-Scene Coordinator and Incident Commander
U.S. Environmental Protection Agency
801 Garfield Avenue, #229
Traverse City, MI 49686

Re: In the Matter of Enbridge Energy Partners, L.P., *et al*,
Docket No. CWA 1321-5-10-001

Dear Mr. Dollhopf:

The United States Environmental Protection Agency (U.S. EPA) in a letter dated December 19, 2011, gave Enbridge Energy, Limited Partnership (Enbridge) notice of Approval with Modifications on the Addendum to the Response Plan for Downstream Impacted Areas, August 2, 2010 (Revised August 17, 2010 per U.S. EPA August 17, 2010 letter), Supplement to Source Area Response Plan, and Supplement to Response Plan for Downstream Impacted Areas, Referred to as Operations and Maintenance Work Plan Commonly referred to as "Consolidated Work Plan for Activities through 2012" dated December 4, 2011.

Enclosed, please find the approved Addendum to the Response Plan for Downstream Impacted Areas, August 2, 2010 (Revised August 17, 2010 per U.S. EPA August 17, 2010 letter), Supplement to Source Area Response Plan, and Supplement to Response Plan for Downstream Impacted Areas, Referred to as Operations and Maintenance Work Plan Commonly referred to as "Consolidated Work Plan from Fall 2011 through Fall 2012" dated December 21, 2011 along with a response to comments log for your convenience.

If you have any questions about these materials, please do not hesitate to contact me.

Sincerely,

ENBRIDGE ENERGY, LIMITED PARTNERSHIP
By Enbridge Pipelines (Lakehead) L.L.C.
Its General Partner

Richard Adams
Vice President, U.S.Operations

CC: Joel W. Kanvik, Enbridge
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627250

RESPONSE TO COMMENTS LOG

Re: Approval with Modifications to Enbridge Energy, Limited Partnership's December 4, 2011 Submittal in response to the Administrative Order issued by U.S. EPA on July 27, 2010 and Supplement to the Administrative Order issued by U.S. EPA on September 23, 2010, pursuant to §311(c) of the Clean Water Act (Docket No. CWA 1321-5-10-001)

U.S. EPA is writing you regarding the following document resubmitted by Enbridge Energy, Limited Partnership, Enbridge Pipelines (Lakehead) L.L.C., Enbridge Pipelines (Wisconsin), and Enbridge Energy Partners, L.P. (herein collectively referred to as "Enbridge") on December 4, 2011:

> *Enbridge Line 6B MP 608, Marshall, MI Pipeline Release, Addendum to the Response Plan for Downstream Impacted Areas, August 2, 2010 (Revised August 17, 2010 per U.S. EPA August 17, 2010 letter), Supplement to the Source Area Response Plan and Supplement to Response Plan for Downstream Impacted Areas, Referred to as Operations and Maintenance Work Plan. Commonly referred to as* ***"Consolidated Work Plan for Activities through 2012,"*** *Prepared for United States Environmental Protection Agency, Enbridge Energy, Limited Partnership, Submitted: October 20, 2011, Revised by the United States Environmental Protection Agency November 17. 2011, Revised by Enbridge Energy', Limited Partnership, Submitted: December 4, 2011*

The U.S. EPA approves Enbridge's above-referenced Consolidated Work Plan for Activities through 2012 ("Work Plan") with the modifications described herein. Please provide and incorporate the following elements into the modified Work Plan:

1. The schedule proposed by Enbridge in the Work Plan is not acceptable. Specifically, the dates proposed for completion of the hydrodynamic model are critical. Accordingly, the completion of the hydrodynamic model shall be accelerated. The schedule for tasks related to the hydrodynamic model (corresponding to line items 38 through 48 on the schedule submitted by Enbridge in the Work Plan) shall be as follows:

• Bathymetry and Terrain Submittal	December 16, 2011
• Grid Setup	December 16, 2011
• Configuration for Flow and Velocity	December 30, 2011
• Analysis of Sediment Samples and Cohesion Data	January 13, 2012
• Complete Configuration including Sediment Processes	January 27, 2012
• Model Calibration	February 10, 2012
• Preliminary and Baseline Model Scenarios	February 24, 2012
• Sensitivity Testing	February 24, 2012
• Develop Scenarios/Various Simulations	March 23, 2012
• Completion of Simulation	March 23, 2012
• Run Modified Scenarios	April 6, 2012

The U.S. EPA will continue to work with Enbridge in modifying and updating the project schedule as needed including, but not limited to, establishing interim milestones for U.S. EPA review.

Response: The schedule in Section 4.3.8 has been updated to reflect these changes.

2. Section 1.6: Figure 1.6.2 (Science Group Support of the OSCAR Process) is missing. Please add the referenced figure.

   Response: Figure 1.6.2 is included in the printed version and the pdf version.

3. Please ensure proper grammar with the use of "data" in its plural form throughout the text.

   Response: Text has been updated.

4. Please add a list of known Outstanding Sites Characterization and Reconciliation (OSCAR) sites to the revised Work Plan.

   Response: Figure 2.2 List of know OSCAR Sites has been added to Section 2.2.

5. Section 2.2:

   a. Page 6, Second Bullet: Please replace the existing text with "All former overbank excavation areas;".

      Response: Page 6, Second Bullet has been modified as requested.

   b. Page 6, Fourth Bullet: Please split the text into two bullets, one per sentence.

      Response: Page 6, Fourth Bullet has been modified as requested.

   c. Page 6, paragraph following bullets: Please convert the first sentence (which starts with "Submerged oil sites identified...") to a bullet and add it to the bulleted list immediately preceding the paragraph.

      Response: Page 6, paragraph following bullets has been modified as requested.

6. Section 4.3.2, the last paragraph on page 23: Reference is made to 4 stages of the adaptive management cycle, but the bullet list now has 5 items. Please correct and revise.

   Response: Section 4.3.2, the last paragraph has been modified as requested.

7. Section 4.3,4, second to last paragraph on page 29: the referenced "SCS" is defined as a "Scientific Certification System": however, previous drafts of the Work Plan defined "SCS" as a "Survey Control Station", Additionally, Table 4.3.2 refers to a "Survey. Control Station", Please ensure that the definition and usage of the referenced "SCS" are correct.

   Response: Text in Section 4.3.4 has been modified as follows: "Terrain data for areas outside the channel and for sub-aerially exposed parts of the channel may be collected on a different day than hydraulic and bathymetric data are collected for each reach; however, the same Quality Assurance ("QA") procedure for opening and closing observations at a Survey Control Station ("SCS") shall be followed for terrain surveys as for bathymetric surveys."

8. Section 4.3.8, Page 35: Please amend the list of hydrodynamic modeling phases to include sensitivity testing.

   Response: The schedule in Section 4.3.8 has been updated to reflect this change.

9. Attachment A, Figure 1: Include all of the inundated (pink) polygons recorded previously during the Spring 2011 reassessment. The Spring 2011 reassessment showed impacts to the two ponds at the Shady Bend Campground and these ponds should be added to the list of reassessment targets.

   Response: Attachment A, Figure 1 has been updated to include the two ponds at the Shady Bend Campground.

10. Attachment B, Figure 1: The Spring 2012 reassessment poling locations need to be expanded. A total of 439 moderate/heavy poling points fall outside the polygons identified in resubmittal of the Work Plan. In some cases, the distance from the point in question to the nearest polygon line is very small (1 to 5 ft); in many other cases there is no polygon line in the near vicinity (>100 ft). All points need to be accounted for in the maps in Attachment B, Figure 1.

    Response: Attachment B, Figure 1 has been updated as requested.

Enbridge Line 6B MP 608
Marshall, MI Pipeline Release

Addendum to the Response Plan for Downstream Impacted Areas, August 2, 2010 (Revised August 17, 2010 per U.S. EPA August 17, 2010 letter), Supplement to Source Area Response Plan, and Supplement to Response Plan for Downstream Impacted Areas, Referred to as Operations and Maintenance Work Plan

Commonly referred to as
"Consolidated Work Plan from Fall 2011 through Fall 2012"

Prepared for the United States Environmental Protection Agency by
Enbridge Energy, Limited Partnership
Submitted: October 20, 2011

Revised by the United States Environmental Protection Agency
November 17, 2011

Revised by Enbridge Energy, Limited Partnership
Submitted: December 4, 2011

Approved: December 21, 2011

CONTENTS

FIGURES

TABLES

ATTACHMENTS

1.0 Introduction

The ***Consolidated Work Plan from Fall 2011 through Fall 2012*** (―Work Plan”) attached herein is an addendum to the following United States Environmental Protection Agency (―U.S. EPA”)-approved documents for the Enbridge Line 6B MP 608 oil spill (―Incident”) which occurred near Marshall, Michigan on July 26, 2010:

- *Response Plan for Downstream Impacted Areas, August 2, 2010 (Revised August 17, 2010 per U.S. EPA August 17, 2010 letter);*
- *Supplement to Source Area Response Plan; and*
- *Supplement to Response Plan for Downstream Impacted Areas, Referred to as Operations and Maintenance Work Plan.*

1.1 Background

This Work Plan was prepared in response to the U.S. EPA’s letter (October 6, 2011) to Enbridge Energy, Limited Partnership, Enbridge Pipelines (Lakehead) LLC, Enbridge Pipelines (Wisconsin), and Enbridge Energy Partners, L.P. (―Enbridge”) requiring modifications to work plans for oil recovery activities to be conducted by Enbridge from Fall 2011 through Fall 2012. The October 6, 2011 U.S. EPA letter requires Enbridge to provide a work plan for continued activities to perform oil assessment, containment, and recovery activities pursuant to the Removal Administrative Order issued by the U.S. EPA on July 27, 2010 and a Supplement to Order issued by the U.S. EPA on September 23, 2010 (―U.S. EPA Order”).

1.2 Regulatory Framework

As required by the U.S. EPA Order, all oil assessment, containment, and recovery activities shall be performed in accordance with Section 311(c) of the Clean Water Act, 33 U.S.C. § 1321(c), as amended by the Oi1 Pollution Act of 1990, and 33 U.S.C. § 2701 et seq. Paragraph 18 of the Removal Administrative Order and Paragraph 6 of the Supplement require, among other things, that Enbridge perform the following actions in response to the Enbridge Line 6B Incident:

1. Assess all oil-impacted areas and media;
2. Contain all oil;
3. Remediate/recover all submerged oil;
4. Recover all oil sheen;
5. Remediate all oil-containing soils;
6. Remediate all oil-containing sediments; and
7. Perform operations and maintenance activities directed by the U.S. EPA.

In addition to the regulations cited above, oil assessment, containment, and recovery activities shall be performed in accordance with all federal, state, and local regulations. Undertaking activities directed by the U.S. EPA does not obviate the need for Enbridge to acquire all necessary permits and comply with other applicable regulatory requirements.

1.3 Purpose and Objective

This Work Plan requires activities designed to improve the understanding of submerged oil transport, containment of oil, and recovery of oil-containing soil/sediment related to the Enbridge Line 6B Incident. Activities and tasks described herein shall be performed from Fall 2011 through Fall 2012.

This Work Plan applies to all affected oil-impacted overbank areas (the areas along the banks and floodplains of the Kalamazoo River) and submerged oil located within the Kalamazoo River (including the Morrow Lake Delta and Morrow Lake). Although the U.S. EPA has transitioned primary oversight authority of oil containment and recovery activities in and adjacent to Talmadge Creek to the Michigan Department of Environmental Quality (―MDEQ"), all activities performed by Enbridge in and adjacent to the Talmadge Creek shall also be compliant with the U.S. EPA Order, and is subject to further review by the U.S. EPA.

In order to address the remaining oil, Enbridge shall evaluate and design a broader range of options to address remaining oil than were employed in 2010 and 2011. Once Spring 2012 reassessments of the Kalamazoo River and overbank have been completed, Enbridge, as directed by the U.S. EPA, shall implement site-specific options for each area to address residual oil and sheen. Options include, but are not limited to, the following:

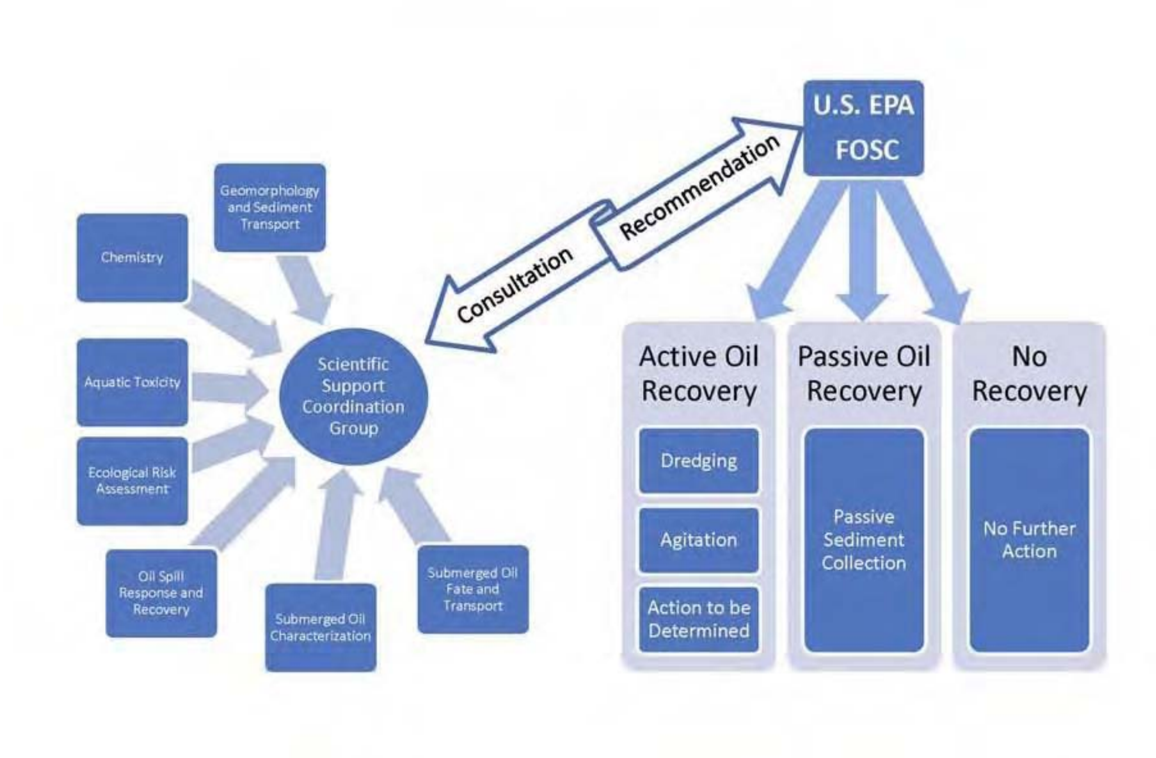
- Dredging of oil-containing sediments;
- Excavation of overbank areas;
- Agitation of sediments coupled with oil/sheen collection;
- Installation of passive sediment collection devices/structures; and/or
- No further action.

1.4 Environmental Protection

As stated above, all response activities shall be governed by applicable regulations, and as directed by the U.S. EPA in the role of Federal On-Scene Coordinator (―FOSC”). Response actions chosen by the U.S. EPA will continue to consider ecological benefits and consequences of recovery activities, engineering feasibility factors, and other scientific factors. Many ecological or scientific consideration incorporated by the U.S. EPA in its directives will be guided by advice from entities commissioned by the U.S. EPA FOSC. These entities are established as the U.S. EPA Scientific Support Coordination Group (―SSC Group”) for the Enbridge Line 6B incident.

All active oil recovery shall include an evaluation of ecological considerations, as well as an evaluation of the potential benefits and consequences of oil recovery, or the lack thereof. Although Enbridge may recommend actions, the decision of adverse ecological risk will be made solely by the U.S. EPA FOSC who will consult with the SSC Group. The supporting role of the SSC Group is demonstrated in Figure 1.4.

Figure 1.4 Scientific Support Coordination Group



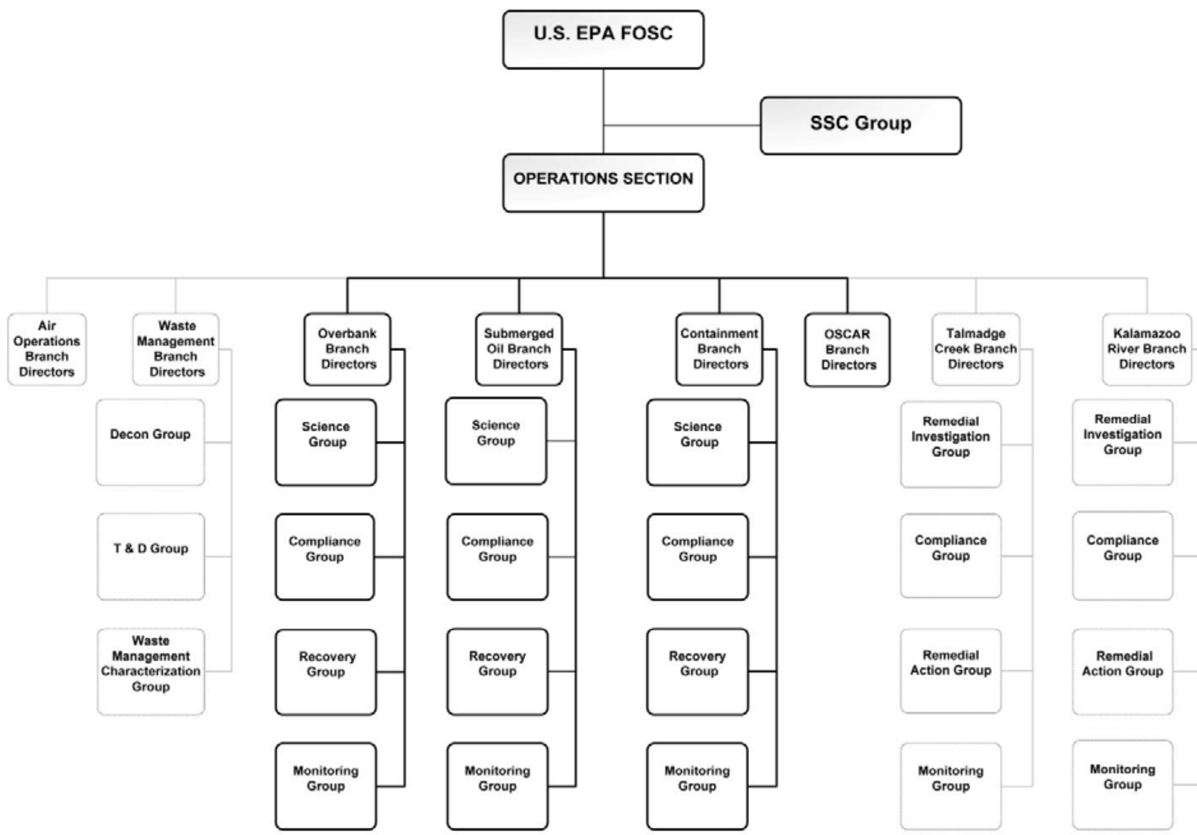
1.5 Adaptive Management

Many of the activities described in this Work Plan are investigative in nature and are designed to provide scientific information that can be used to further refine assessment, containment, and/or oil recovery activities. Therefore, future findings of assessment and investigative activities may affect the viability and/or effectiveness of activities described herein. Findings of investigative activities shall be evaluated and considered in an iterative fashion when determining tactics and strategies to accomplish the overall objectives of the work. However, any changes to the activities described must be approved by the U.S. EPA prior to changing this Work Plan and/or implementation of activities.

1.6 Organizational Structure

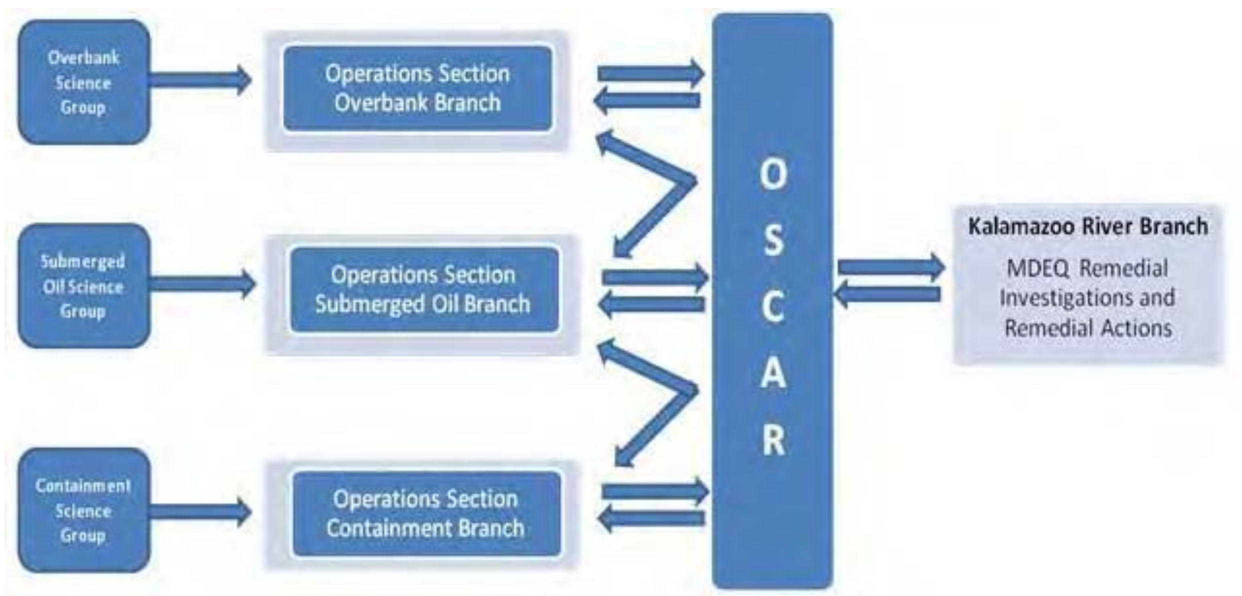
An organizational structure has been established in conjunction with the U.S. EPA to optimize implementation of this Work Plan. The organizational structure has been adopted into the Incident Action Plan and has been used to coordinate, guide, and evaluate reassessment, scientific studies and oil recovery activities while providing a critical communication tool. The organizational structure is dynamically designed to be refined and modified to adapt to changing project conditions, clean up progress, and shifting command emphasis.

Figure 1.6.1 Organizational Structure



Critical components of the organizational structure are the science groups, branch directors, the Outstanding Sites Characterization and Reconciliation (–OSCAR") Branch and FOSC. As depicted in the figure below, the science groups contained within the branches advise the branch directors based on an evaluation of information that is compiled and evaluated. The branch directors present their evaluation and recommendations to the OSCAR Branch. The OSCAR Branch evaluates the data and determines if further action is necessary for each site under the U.S. EPA Order or if site transition to the MDEQ is appropriate. Further detail about the OSCAR Branch is provided in Section 2.0.

Figure 1.6.2 Science Group Support of the OSCAR Process



2.0 OUTSTANDING SITES CHARACTERIZATION AND RECONCILIATION

The U.S. EPA established the OSCAR process during 2011 reassessment and recovery activities. The OSCAR process shall continue during 2012 with the objective to compile a single list of impacted and unresolved sites along the Kalamazoo River, and Morrow Lake. The OSCAR Branch shall be comprised of Enbridge, the U.S. EPA, and MDEQ.

2.1 Objectives

The OSCAR Branch will determine a course of action for each site until no further action is required under the U.S. EPA Order.

2.2 Methods and Procedures

To reach this goal, qualitative assessments will be conducted by the respective operations branch at each unresolved site to characterize the nature and extent of remaining oil impact. A vegetative assessment at each site will be conducted concurrently with the qualitative assessment to determine if the location meets the MDEQ criteria for wetland areas of potential high value criteria. Once the assessment is complete for a given site, the respective operations branch shall evaluate the current and historical data, and present the information to the OSCAR Branch. Based on the information presented, the OSCAR Branch will determine if recovery or assessment actions should be implemented next at that site.

The OSCAR Branch evaluates information associated with the following general reassessment sites:

- Overbank pond and back-water areas identified as ―Strike" sites during 2011 SORT reassessment and recovery activities;
- All former overbank excavation areas;
- Un-reconciled O&M sites that have not been determined to have had response action completed consistent with the U.S. EPA Order;
- 2011 Late Summer Reassessment (―LSR") poling delineated areas, LSR data gaps, and other sites identified by the Shoreline Overbank Science Group (―SOSG");
- New sites including shoreline and overbank areas and other locations identified via monitoring, aerial over-flights, or other means;
- Impacted overbank areas identified during 2012 SORT reassessments; and
- Submerged oil sites identified during the 2012 submerged oil reassessment.

The OSCAR Branch shall evaluate all available information for each site, and make a determination as to whether or not response actions have been completed at each site consistent with the U.S. EPA Order and ready for future management under Part 201 of Michigan Act 451 of 1994 as amended (―Part 201"). If the OSCAR Branch determination is that the site no longer needs response under the Order, then the OSCAR Branch will recommend that the site be transitioned to the MDEQ. If the site is determined to need further response work pursuant to the Order, the OSCAR Branch will make a recommendation to the appropriate operations branch to complete all work necessary at the site. These recommendations may include, but are not limited to, one of the following:

- Additional qualitative assessment activities;
- Additional recovery operations using approved methods;
- Transfer of the site to the appropriate branch;
- Initiation of an expedited Remedial Investigation (RI) pursuant to MDEQ Part 201;
- Permitted recovery operations under the U.S. EPA Order; and/or
- No further action.

If response work is required, a site specific work plan shall be submitted to the U.S. EPA that outlines the specific actions that shall be taken to ensure that the site no longer needs response pursuant to the Order. Upon completion of any response work, the OSCAR Branch will re-evaluate each site consistent with the OSCAR process. The OSCAR process will be continued as needed until all sites are transitioned to the MDEQ. A list of known OSCAR sites, current to the printing of this Work Plan, is demonstrated in Figure 2.2.

Figure 2.2 List of known OSCAR Sites

Outstanding Site Characterization and Reconciliation (O.S.C.A.R.)

MP	Site ID	Status
0.75	Talmadge Creek Culverts	
2.25	CB 2.00	
2.25	CB 2.07	
4.25	SO 4.15 South AA	
4.25	SO 4.15 South AC	
4.25	SO 4.25 Center	
4.50	SO 4.3 South B	
4.50	SO 4.40T AA	
4.50	SO 4.40T AB	
4.50	SO 4.40T B	
4.75	SO 4.6 Center	
4.75	SO 4.6 South	
4.75	SO 4.7 South	
5.00	SO 4.8 South	
5.00	SO 4.8 North A	
5.00	SO 4.8 North B	
5.00	SO 4.8 Center	
5.00	SO 4.9 South A	
5.00	SO 4.9 South B	
5.00	SO 4.9 South C	
5.00	SO 4.9 South D	
5.25	SO 5.25 North A	
5.25	SO 5.25 North C	
5.75	SO 5.55 North/5.35 North A	
5.75	SO 5.55 North/5.35 North B	
5.75	SO 5.55 North/5.35 North C	
5.75	SO 5.55 North/5.35 North D	
5.75	SO 5.55 North/5.35 North E	
5.75	SO 5.55 North	
5.75	SO 5.63 South	
5.75	SO 5.75 Northwest	
5.75	SO 5.75 South A	
5.75	SO 5.75 South B	
5.75	SO 5.75 Center	
6.00	SO 5.9 North	
6.00	SO Main St. Bridge SW	
6.00	SO 5.9 South A	
6.00	OB 5.92 RDB	
6.25	SO 6.25 R1	
6.50	SO 6.41T	
6.50	SO 6.45 North A	
6.75	SO 6.68T	
7.00	SO 7.0R1 B	
7.00	SO 7.0 South	
8.00	SO 7.75	
8.25	OB 8.22 I	
8.25	SO 8.25 I1 A	
8.25	SO 8.25 I1 B	
8.25	SO 8.25 I2 A	
8.25	SO 8.25 I2 B	
8.50	SO 8.43T	
8.50	OB 8.48 LDB	
8.50	SO 8.50	
8.50	SO 8.5 L1	
8.50	SO 8.5 L3	
8.75	SO 8.75 North B	
8.75	SO 8.59	
9.00	OB 8.97 I	
9.00	SO 9.0 I2 A	
9.00	SO 9.0 I2 B	
9.00	SO 9.0 I3	
9.00	SO 9.00	
9.00	OB 9.10 LDB	
9.25	SO 9.25 L1	
9.50	SO 9.45T	
9.50	SO 9.5 I1 A	
9.50	SO 9.5 I1 B	
9.50	SO 9.5 I1 C	
9.75	SO 9.75 South A	
9.75	SO 9.75 South B	
10.00	SO 10.0 Center	
10.25	SO 10.17T	
10.25	SO 10.2 South	
10.25	SO 10.21T	
10.25	SO 10.25 North	
10.50	OB 10.37 RDB	
10.50	SO 10.4 North	
10.50	SO 10.5 North	
10.75	SO 10.65T A	
10.75	SO 10.65T B	
10.75	SO 10.65 North	
10.75	SO 10.75 L2	
11.00	SO 10.8 South	
11.00	SO 10.89T A	
11.00	SO 10.89T B	
11.00	SO 10.89T C	
11.25	SO 11.16T	
11.25	SO 11.21	
11.25	SO 11.25 R1	
11.25	SO 11.25R2 A	
11.25	SO 11.25R2 B	
11.25	SO 11.25R2 C	
11.75	OB 11.79 LDB	
12.50	SO 12.45T	
12.50	SO 12.50	
12.50	OB 12.56 LDB	
12.75	SO 12.75 I1	
13.00	SO 12.91T	
13.00	OB 13.04 RDB	
13.25	SO 13.25 North	
13.25	SO 13.25 L1	
13.50	OB 13.40 LDB	
13.50	SO 13.5 L1	
13.75	SO 13.6 South	
14.00	SO 13.85 North	
14.00	SO 13.85 South A	
14.00	SO 13.85 South B	
14.00	SO 13.95 North	
14.00	SO 14.0 I1	
14.25	SO 14.2 South	
14.50	SO 14.35 North A	
14.50	SO 14.35 North B	
14.50	SO 14.35 North C	
14.50	SO 14.40T B	
14.75	SO 14.6 South	
14.75	SO 14.75 A	
14.75	SO 14.75 B	
14.75	SO 14.75 C	
14.75	SO 14.75 L1 A	
14.75	SO 14.75 L1 B	
15.00	SO 14.8 South	
15.00	SO 14.9 South A	
15.00	OB 14.97 I	
15.00	OB 14.98 I	
15.25	SO 15.05 South B	
15.25	SO South Mill Pond AA	
15.25	SO South Mill Pond AB	
15.25	SO South Mill Pond AC	
15.50	SO 15.25	
15.50	SO 15.4 A	
15.50	SO 15.4 B	
15.50	SO 15.4 C	
15.75	SO North Mill Pond A	
15.75	SO North Mill Pond B	
17.00	SO Rock-Tenn	
18.25	SO 18.15 South	
18.50	SO 18.5 South	
18.75	SO 18.65 South	
19.00	SO 18.8 Center A	
19.00	SO 18.8 Center B	
19.00	SO 18.85 North	
19.00	SO 18.95 North	
19.25	SO 19.15 South	
19.25	SO 19.25 L1	
19.25	SO 19.25 L1 AA	
19.50	SO 19.45 North	
19.50	SO 19.47T	
19.75	SO 19.56T	
20.25	SO 20.1 South	
20.75	SO 20.63T	
21.25	SO 21.11T	
21.50	SO Custer Dr Bridge SW	
21.50	SO 21.4	
21.50	SO 21.50	
21.75	SO 21.54T	
21.75	SO 21.55 South	
22.25	SO 22.25T	
22.75	SO 22.75 North	
23.75	SO 23.54T	
24.00	SO 23.83T	
24.75	SO 24.65 South	
25.00	SO 24.82T	
25.00	SO 24.92T	
25.75	SO 25.7 North	
26.25	SO 26.0	
26.25	SO 26.13T	
25.50	OB 26.23 LDB	
26.25	OB 26.25 RDB	
26.25	SO 26.25	
26.75	SO 26.65 A	
26.75	SO 26.65 B	
27.00	SO 26.8 Southeast	
27.25	SO 27.02T	
27.25	SO 27.1 North	
27.25	SO 27.15 South	
27.75	SO 27.7 North	
28.00	SO 27.9	
28.25	SO 28.15 South	
28.25	SO 28.25	
28.50	SO 28.28T	
28.50	SO 28.34T	
28.50	SO 28.39T	
28.50	SO 28.45 South A	
28.50	SO 28.45 South B	
28.50	SO 28.47T	
28.50	SO 28.5 North	
28.75	SO 28.65T	
28.75	SO 28.75 North	
29.00	SO 28.9 South	
30.75	SO 30.7 North	
31.00	SO 30.8 South B	
32.25	SO 32.15	
31.25	SO 31.25 North	
32.75	SO 32.65 Southeast	
33.00	SO 32.89	
33.00	SO 33.00 L1	
34.50	SO 34.48T	
36.00	SO 35.84T A	
36.25	SO 36.23 RDB	
36.50	SO 36.45 North	
36.75	SO 36.6 South B	
36.75	SO 36.75 North	
36.75	SO Delta A	
37.00	SO Delta BA	
37.00	SO Delta BB	
37.00	SO Delta G	
37.00	SO Delta I	
37.25	SO 37.1 North	
37.25	SO Delta M	
37.25	SO Delta N	
37.25	SO Delta P	
37.25	SO Delta Q	
37.50	SO Delta FF	
37.50	SO Delta GG	
37.50	SO Delta HH	
38.50	SO Lake J	

LEGEND

3	Overbank Branch
198	Submerged Oil Branch
5	Containment Branch
1	Talmadge Creek Branch
7	Kalamazoo River Branch
2	CONSISTENT W/ EPA ORDER and up for MDEQ Part 201 Program Consideration

216 Total

3.0 REASSESSMENT OF OIL LOCATION AND EXTENT

3.1 Shoreline and Overbank Reassessment

3.1.1 Objectives

The shoreline and overbank along the Kalamazoo River downstream impacted areas will be reassessed in Spring 2012. Supplemental qualitative reassessments may be conducted as discussed in Section 3.1.4. The objective of the Spring 2012 reassessment is to determine the presence or absence of oil and/or oil sheen along targeted overbank areas along the affected river system from MP 2.25 of the Kalamazoo River to the Morrow Lake Dam. The information collected during the Spring 2012 Reassessment will be compared with previous overbank assessment results to determine what additional overbank recovery activities are required.

An Overbank Science Group (―OSG”) shall be established to review data associated with overbank assessments and recovery activities. The OSG shall be comprised of Enbridge, the U.S. EPA, and MDEQ. The overall goal for the OSG will be to ensure reassessment data quality and completeness, evaluate overbank oil recovery tools and effectiveness, and to make recommendations to OSCAR for each reassessment site.

To reach this goal, the OSG shall review and evaluate the following data on an ongoing basis throughout Fall 2011 and continuing through Fall 2012:

- Historic and ongoing assessment data; and
- 2012 reassessment results.

The OSG shall consult and coordinate with the OSCAR Branch to discuss findings and to provide recommendations for overbank oil reassessment and recovery operations.

3.1.2 Spring 2012 Reassessment Methods and Procedures

Targeted locations shall be qualitatively reassessed during Spring 2012 according to the Shoreline Overbank Reassessment Technique (―SORT”) procedures developed and utilized during Spring 2011. SORT teams shall be comprised of one U.S. EPA Superfund Technical Assessment and Response Team (―START”) or U.S. EPA representative, one MDEQ representative, and Enbridge representative(s). SORT teams shall complete the following tasks for each targeted reassessment location:

- Characterize oiling conditions and substrate types using a standardized terminology (SORT Metric Quick Guide);
- Characterize shoreline and overbank habitat types and the degree and characteristics of any oiling conditions;
- Record percent cover of a specific oiling condition within a point/zone on field maps and data collection forms;
- Collect a waypoint and/or polygon dimensions for each of the oiled points/zones identified as potentially needing additional response activities using a Global Positioning System (―GPS”) unit with sub-meter accuracy;

- Identify and estimate the area of impact of specific oiling and substrate conditions observed during current conditions;
- Determine whether the impacted area is characterized as a sensitive habitat according to the MDEQ Water Resources Division (―WRD”); and
- Assign site identification nomenclature prescribed by the OSCAR Branch to avoid conflict with historic naming conventions (2010 Shoreline Cleanup Assessment Techniques (―SCAT”), 2011 SORT, O&M, etc.).

3.1.3 Spring 2012 Reassessment Sites

Spring 2012 SORT activities shall focus on, but not be limited, to the following sites:

- Former excavation areas;
- Impacted areas identified during the 2011 SORT reassessment that were inundated during the 2011 SORT reassessment activities (including Strike sites); and
- Impacted areas identified as having ―Film”, ―Sheen”, and/or ―Pooled Oil” during the 2011 SORT reassessment.

Shoreline and overbank sites currently targeted for reassessment are presented in Attachment A. Data obtained for each site shall be uploaded to the GIS database using the appropriate naming and symbol conventions. SORT data for each site shall also be added to the OSCAR list and presented to the OSCAR Branch for review and evaluation. The OSCAR Branch shall review all current and historic information for each reassessment site to determine whether sites have been or shall continue to be addressed under the U.S. EPA Order or transitioned to the MDEQ.

3.1.4 Supplemental Qualitative Assessments

Supplemental qualitative assessment activities shall be conducted on an ongoing basis to characterize any remaining oil and/or oil sheen from areas identified from the OSCAR process.

3.1.4.1 Supplemental Qualitative Assessment Methods and Procedures

Supplemental qualitative assessment activities will be conducted by the OSG to assess if further actions are needed under the U.S. EPA Order. The qualitative assessments shall include screening techniques to determine the presence or absence of oil and/or oil sheen including the following:

- Visual examination of exposed surface soils and vegetation to determine the presence and extent of any pooled oil, residual oil accumulations, oil film, or oil sheen;
- Poling assessment of any overbank areas that remain submerged at the time the inspections are performed, using approved poling techniques;
- Visual and ultraviolet (―UV”) screening of soil cores collected using hand-augers or other means according to applicable Standard Operating Procedure (―SOPs”);
- Visual assessment of soils/mud flats/dried overbank ponds and backwater areas according to the Bucket Sheen Test SOP, approved by the U.S. EPA in correspondence dated October 11, 2011;

- Visual assessment of soils/mud flats/dried overbank ponds and backwater areas according to the Poling Ring Test SOP approved by the U.S. EPA in correspondence dated October 11, 2011; and
- Aerial over-flight photo log review.

Core sample collection shall be performed in accordance with procedures described in the existing approved Sampling and Analysis Plan (SAP, Enbridge, 2011). Procedures for performing and evaluating UV screening of soil cores shall be described in a separate SOP to be submitted and approved by the U.S. EPA prior to undertaking the work.

3.2 Submerged Oil Reassessment

3.2.1 Objectives

The 2012 submerged oil reassessment scope of work shall include site-wide poling of river sediments. Supplemental poling reassessments may be conducted as discussed in Section 3.2.5. Data obtained from submerged oil reassessment activities shall be used for comparison to 2010 and 2011 submerged oil data sets, and to make determinations as to the distribution and relative quantity of submerged oil remaining in the river. Submerged oil reassessment information shall be used in conjunction with other considerations to direct all future submerged oil recovery actions. Additional focused poling within specific sub-areas of the river shall be performed, as determined by the SOSG.

The SOSG shall be established to review data associated with submerged oil assessment and recovery activities. The SOSG shall be comprised of Enbridge, the U.S. EPA, United States Geological Survey (―USGS"), and MDEQ. The overall goal for the SOSG will be to ensure reassessment data quality and completeness, evaluate submerged oil recovery tools and effectiveness, as well as to provide recommendations for the placement of sediment traps and to make recommendations to OSCAR for each reassessment site.

To reach this goal, the SOSG shall review and evaluate the following data on an ongoing basis throughout Fall 2011 and continuing through Fall 2012:

- Historic poling data;
- Sediment core data;
- Hydrodynamic assessment data;
- Hydrodynamic modeling data;
- Temperature effects studies data;
- Submerged oil quantification data;
- 2012 Reassessment results;
- Containment placement, monitoring, and removal; and
- Placement, monitoring, and maintenance of oil-containing sediment traps.

The SOSG shall consult and coordinate with the OSCAR Branch to discuss findings and to provide recommendations for submerged oil reassessment and recovery.

3.2.2 Spring 2012 Reassessment Methods and Procedures

Targeted locations shall be qualitatively reassessed during Spring 2012 according to the procedures developed and utilized during Spring 2011. Submerged oil reassessment activities shall include poling of soft sediments in targeted depositional areas. Data associated with poling including water depth, pole advancement depth, soft sediment thickness, bed characteristics, the presence/absence of oil, GPS coordinates, and the relative amount of oil/sheen shall be collected at each location.

Water depth data shall be collected using a 6-inch diameter disk attached to the end of an aluminum pole approximately 2 inches in diameter marked at 0.1-foot intervals. At each poling location, the disc shall gradually be lowered to the top of the sediment bed, and the depth from the water surface to the top of soft sediment (water depth) shall be recorded to the nearest 0.1-foot.

Soft sediment thickness data shall be collected using a pole without a disk and marked at intervals of 0.1-foot. The pole shall be pushed vertically through the sediment until advancement is restricted. The depth to sediment surface (water depth) and maximum poling depth into the soft sediment shall determine the soft sediment thickness at each location. A description of the sediment type shall be documented based on the poling results (e.g., soft sediment – silt over sand).

An approximate determination of the relative amount of submerged oil at each poling location shall be made by using the pole with a 6-inch diameter disk to agitate the soft sediment. After agitation, the amount of oil/sheen observed at the water surface shall be described using the same categories as the 2011 field season (heavy, moderate, light, or none). These categories are outlined in the attached Submerged Oil Field Observation Flow Chart (Figure 1). If ―moderate” or ―heavy” indications of submerged oil sheen/globules are observed, the area shall be delineated with additional poling. The poling teams shall work away from the ―moderate” or ―heavy” location until they have poled either a ―light” submerged oil classification, or no indication of submerged oil.

A GPS unit shall be used to document the coordinates for each poling location. All poling locations shall be surveyed during the project to the extent practicable using a differential GPS unit with sub-meter accuracy. The horizontal coordinate system shall be the Michigan State Plane Coordinate System, South zone, referenced to the North American Datum (―NAD”) 83, in international feet.

All poling activities shall be conducted during optimal temperature conditions as determined via an evaluation of the results from temperature effects on submerged oil studies as described herein. As such, sediment and water temperature data shall be collected during poling activities as thresholds for data reliability are approached.

3.2.3 Spring 2012 Reassessment Poling Locations and Frequency

Site-wide poling shall be conducted in targeted areas along the Kalamazoo River from the confluence of Talmadge Creek and the Kalamazoo River to the Morrow Lake Delta, within Morrow Lake and at additional areas downstream of the Morrow Lake Dam. Poling activities shall be focused in depositional areas with soft bed sediment types since submerged oil is most often associated with depositional geomorphic environments. Poling locations shall be minimal in erosional or bed-material transporting areas with sand/gravel bed types, because submerged oil is not typically associated with this these higher river velocity geomorphic settings.

Poling shall be conducted at the following locations:

- All locations where moderate or heavy submerged oil was identified during the 2010 and 2011 field seasons, including areas identified during 2011 LSR locations;
- Within all 2011 focus areas;
- Additional poling boundaries;
- At select transect locations; and
- As directed by the U.S. EPA.

Additional poling targets extending from approximately MP4.0 to Ceresco Dam, from approximately MP14.0 to Battle Creek Dam, and within the engineered channel portion of the river from approximately MP18.0 to 20.0 may be added if determined by the SOSG. Additionally, any areas identified from the hydrodynamic assessment or hydrodynamic modeling results as potential depositional areas, and not previously poled, will be added to the list of targets for the 2012 site-wide poling. For all these areas, crews shall visually assess the area and select representative poling locations. The crews may add poling locations to an area based on field observations. Proposed site-wide poling locations for the Spring 2012 Reassessment are presented in Attachment B, Figure 1.

Poling locations on the Morrow Lake fan shall be determined by the SOSG. Poling locations within Morrow Lake shall be comparable to the areas presented in the Addendum to the Spring 2011 Overbank and Poling Reassessment Work Plan. Additional required poling data collection downstream of the Morrow Lake Dam is described in Section 4.2.1 of this work plan, and the targeted locations are summarized therein.

3.2.4 2012 Late Summer Reassessment

The purpose of the 2012 LSR is to determine the status of submerged oil after any 2012 recovery operations have been completed. The existing U.S. EPA approved poling SOP will be used to perform poling at a level-of-effort recommended by the SOSG. The poling will be conducted using a top-to-bottom approach after oil recovery work has been completed. The poling locations shall be biased to depositional areas to determine the effectiveness of the recovery activities.

3.2.5 Supplemental Poling

Supplemental poling activities will be conducted where recommended by the SOSG, if necessary, to assess if further actions are needed under the U.S. EPA Order. Supplemental poling methods and procedures will be the same as those described in Section 3.2.2 above.

3.3 Data Collection and Documentation

Electronic field data forms shall serve as a daily record of events, observations, and measurements during all shoreline, overbank, and submerged oil field assessment activities. All information shall be recorded electronically on these forms and shall include:

- Names of field crew;
- Date and time of site entry and exit;
- Location of activity;
- Site description;

- Field measurements;
- Field observations; and
- Photographs.

Paper copies of the field forms shall be printed and filed for hard copy backup of all data collected. In addition, all electronic data shall be downloaded to a server at the end of each work day and stored in a GIS database. GIS is used to organize data and to display the data in map form. Location information, field observations, media characteristics, utility information, and results are stored in the GIS database.

3.4 Data Analysis

All reassessment results shall be uploaded to the GIS database on an ongoing basis, and shall be reviewed by the OSG and/or SOSG, as appropriate. Data generated during shoreline, overbank, and submerged oil reassessment activities shall be used along with other data sets to determine additional reassessment data collection needs, and to make informed decisions regarding recovery targets as well as appropriate active and/or passive recovery strategies and tactics.

4.0 SUBMERGED OIL CHARACTERIZATION

Submerged oil characterization includes the hydrodynamic assessment, hydrodynamic model, temperature effects on submerged oil study, and submerged oil quantification. The hydrodynamic assessment includes poling in Morrow Lake, poling downstream of the Morrow Lake Dam, cohesion and erodibility tests, water velocity profiling, sediment core collection, and understanding of sediment transport. The hydrodynamic model consists of setup, data analysis, data inputs, and evaluation of the results. The temperature effects on submerged oil is a bench scale study to better understand the effects that water and sediment temperatures have on submerged oil liberation and the subsequent effectiveness of recovery methods. Submerged oil quantification is a model used to calculate the volume of submerged oil from representative sediment cores and poling data collected throughout the affected area.

4.1 Objectives

The overall objective of submerged oil characterization is to understand its fate and transport related to recovery and containment. Four areas, hydrodynamic assessment, hydrodynamic modeling, temperature effects study, and submerged oil quantification have been identified as critical to this understanding and are further described herein.

4.2 Hydrodynamic Assessment

Data shall be collected to evaluate the fate and transport of fine-grained sediment, submerged oil, and oil-containing sediment in the affected river system (Talmadge Creek, Kalamazoo River, Morrow Lake Delta, Morrow Lake fan, and Morrow Lake). Data shall be collected in cooperation with the SOSG. The primary objectives of the hydrodynamic assessment are to:

- Develop an understanding of the physical and chemical behavior associated with the migration, mobilization and recovery of submerged oil and oil remaining in riverine sediment, including, but not limited to, the effects of temperature and river velocity on the migration of submerged oil.
- Identify physical patterns and migration rates of submerged oil along channel bars, impoundments, and delta/fan environments caused by including high flow, low flow, seasonal/diurnal variation, and oil recovery/assessment activities;
- Optimize and focus submerged oil recovery strategies;
- Evaluate effectiveness of submerged oil recovery operations; and
- Provide support for quantification of submerged oil in riverine sediment.

4.2.1 Poling in Morrow Lake Downstream of Fan

Qualitative assessments using poling techniques shall be performed at locations and frequencies similar to 2010 pre-recovery, Spring 2011 reassessment activities, and routine monitoring points established during the 2011 recovery activities. Additional information collected with the descriptions of oil/sheen shall include geo-referenced locations, qualitative velocity, water depth, soft sediment depth, and qualitative substrate descriptions. Enbridge shall perform poling as specified below:

- Poling locations upstream of Morrow Lake Dam:
  - Poling locations shall have their horizontal coordinates recorded with sub-meter accuracy using differential GPS receivers. For subsequent surveys, the initial poling locations shall be resurveyed to detect change.
  - Poling locations shall be well distributed across the Morrow Lake fan upstream of the control point E4.5 double chevron, and well distributed within and along the downstream side of the double chevron, extending westward until no further indications of submerged oil are detected.
  - If the area where submerged oil indications are detected expands, then the monitored area and number of poling locations also shall increase accordingly.
  - Locations shall be reviewed and updated in consultation with the SOSG.
- Poling frequency upstream of Morrow Lake Dam:
  - Poling will be conducted daily in the Morrow Lake fan during submerged oil recovery operations but each monitoring point will not be completed daily. In 2011, the 40 monitoring point cycle was completed every second day:
  - Post-recovery at least 24 hours but not more than 60 hours after completion of submerged oil recovery operations at a site and downstream of the given site;
  - At least once each season when (Fall 2011, Spring 2012, Summer 2012, and Fall 2012) water temperature is greater than 45°F or the temperature threshold determined in the temperature study described in herein; and/or
  - After large flood events (two year or higher) in 2012. Poling after multiple floods within a three month period, shall occur more than once if the difference in recurrence interval between floods is 5 years or higher.
- Focus area poling locations downstream of Morrow Lake Dam (e.g., next likely depositional areas):
  - Immediately downstream of the Morrow Lake Dam, in left backwater area at MP 39.9 South;
  - Margin of a bend on the left descending bank at MP 40.3 South;
  - Downstream side of a mid-channel island at MP 40.9 North;
  - North side channel margin at MP 41.1 North and upstream of River St. Bridge; and
  - Upstream end of an oxbow at MP 41.25 North (downstream of River St. and upstream of King Hwy).

Focus area poling locations downstream of Morrow Lake Dam are shown in Attachment C, Figure 1. A minimum of five poling locations shall be collected at each focus area. During the initial poling survey conducted in Fall 2011, the poling locations were selected in the field to be representative of the focus area based on sediment thickness, water depth, and water velocity. Poling locations shall have their horizontal coordinates recorded with sub-meter accuracy using differential GPS receivers. For subsequent surveys, the initial poling locations shall be resurveyed to detect change.

- Poling frequency downstream of Morrow Lake Dam:
  - At least once each season when (Fall 2011, Spring 2012, Summer 2012, and Fall 2012) water temperature is greater than the temperature threshold determined in the temperature study described herein; and/or
  - After large flood events (two year or higher) in 2012. Poling after multiple floods within a three month period, shall occur when the difference in recurrence interval between flood events is 5 years or greater.

If submerged oil is found downstream of the Morrow Lake Dam, the poling locations shall be re-evaluated with the SOSG.

4.2.2 Cohesion and Erodibility Tests

The purpose of these tests is to provide information on specific sediment characteristics and their effect on submerged oil migration and transport under typical Kalamazoo River temperature and velocity conditions.

A literature search has been initiated to identify other project work that may have produced similar data based on the particle size and the river type. This literature search data and the site specific data shall inform selection of appropriate values for hydrodynamic parameters, including cohesion, critical shear stress, and erodibility, which shall be used in the hydrodynamic model (described herein). The specific field techniques have been selected in consultation with the U.S. EPA and USGS and shall commence in Fall 2011. The locations of the 15 in-situ jet tests selected in consultation with the USGS are shown in Attachment C, Figure 2. The test locations include the following:

Table 4.2.2 In-situ Jet Testing Locations.

Location	Geomorphic Setting	Surface particle size (top six inches)
5.25 South	Upstream of dam; increased channel width	Silt loam to 4.5’
5.75 South A	Upstream of dam	Silt loam to 2.3’
10.75 L2	Backwater; high flow cutoff channel	Silt loam over sand – adjust toward shoreline
12.5 C	Oxbow	Sandy loam with visible oil – adjust toward shoreline
14.35 North	Upstream of dam; increased channel width	Silt loam over sand – visible oil – adjust toward shoreline
14.75 A	Cutoff channel	Sand over coarse sand – move location further into cutoff channel and near shoreline
South Mill Pond	Upstream of dam; pond	Silt to 3.3’
19.25 L1	Cutoff channel	Silt loam to 0.7’
21.5	Oxbow	Silt loam to 0.8’

Location	Geomorphic Setting	Surface particle size (top six inches)
26.0	Increased channel width; man-made area	Loamy fine sand – visible oil – adjust location near shoreline
30.8 South	Increased channel width; tributary input	Silt loam to 1.5’
36.25 A	Outside meander bend; upstream of island	Loamy sand – no visible oil – move to 36.25 C; SEKR3650C0a; Downstream of island
Morrow Lake Delta H	Sandy bed in consistent depositional area	Sand over loamy sand – no visible oil – adjust location near shoreline or downstream of island (South)
Morrow Lake Delta Z	Soft bed in deposition area	Silt loam to 0.7’
Morrow Lake fan	Near mouth of neck	Silt loam to 0.5”

At three locations - 5.75 South A, 21.5 Oxbow, and Morrow Lake Fan - water depths were greater than 6 inches which required collection of a representative sample of the bottom material with a box corer or other device. In this situation, jet tests shall be conducted on the core samples at a nearby location in the field, with minimal disturbance to the surficial layer of the core.

Results shall be reviewed by the SOSG to determine if adequate coverage exists or if additional testing is necessary. When complete, a test completion report shall be prepared, describing actual field methods and materials, site and sample characteristics, test results, evaluations, and conclusions concerning cohesion and erodibility.

4.2.3 Water Velocity Profiling

Existing hydrodynamic data consist of estimated velocity ranges and current-meter point measurements at discrete poling locations throughout the river system during a narrow range of streamflow conditions. Multi-dimensional understanding of velocity distributions and profiles is needed for adequately describing bed shear stresses under a much wider range of streamflow conditions.

An Acoustic Doppler Velocimeter (―ADV”) or Acoustic Doppler Current Profiler (―ADCP”) shall be used to measure velocities in the x, y, and z directions. Both types of velocity meters collect 3-dimensional data, but the ADCP can collect data continuously along transects as a full vertical profile, whereas the ADV measures velocities at a single point. Both sets of data are needed to more accurately estimate shear stress on the bed and banks of the river. The preference shall be to use the ADCP in the Morrow Lake Delta and fan if the water depths are sufficient for its use. Shallow water depths on the Kalamazoo River may require the use of a hand-held or pole-mounted ADV.

The ADCP shall be properly calibrated prior to any data collection for this study in accordance with manufacturer's specifications and instructions; this shall include site-specific calibration in relation to speed of sound through the river water, and to account for geo-magnetic field variation that can affect the measured flow-direction results.

Daily quality-assurance tests of the ADCP instrument's operational performance (360-degree rotational closure, loop closure, etc.) shall be conducted and results recorded.

Data shall be used to determine migration/transport rates for sediment which may include submerged oil, and also for calibration/validation of the hydrodynamic model. Velocity data shall be collected at the following locations and times:

- Horizontal and vertical velocities at cross-sections (at varying river stages) in specific geomorphic areas including:
    - Morrow Lake fan (at least three latitudinal profiles and four longitudinal profiles);
    - Each side of existing containment location E4.5 (if present);
    - Morrow Lake Delta channels;
    - 35th Street Bridge;
    - Neck of delta and downstream of the neck on the Morrow Lake fan to determine velocity changes longitudinally; and
    - Kalamazoo River: Representative river reaches to evaluate the flow patterns associated with depositional areas, the thalweg, dam impoundments, meanders, oxbows, cutoff channels, and changes in channel width. Selection of representative reaches coordinated with and approved by the U.S. EPA and USGS.
- Horizontal and vertical velocities to evaluate stream-wise changes in velocity along longitudinal transects located at selected, key reaches, including:
    - 35th Street to the Morrow Lake fan;
    - MP 3.0 to Ceresco Dam; and
    - Other reaches of concern in depositional areas where the number of available velocity readings does not adequately explain the river flow pattern. Selection of these reaches coordinated with and approved by the U.S. EPA and USGS.
- At least once each season (Fall 2011, Spring 2012, Summer 2012, and Fall 2012); and/or
- During mean flow conditions;
- During low flow conditions; and
- During high flow conditions (e.g., various flows above median values, including a minimum of two high-flow conditions; high flows are defined as those in the 3rd quartile and 4th quartile of the flow-duration table). High-flow data collection is conditioned upon the actual occurrence of those flow conditions within the study period and task schedule. During high flow events, the ADCP may be used from bridges for compliance with safety policies.

Provisional locations of cross-sectional and longitudinal transects where velocity profiles shall be measured are shown in Attachment C, Figure 3. The USGS shall provide data for velocity profiles and cross-sections from discharge measurements made at the existing gauging stations (at bridge locations), if available. Final selection of velocity profile locations were made in consultation with and approved by the U.S. EPA and USGS.

4.2.4 Surficial Streambed Sediment Characteristics

Existing data consist of pre- and post-recovery cores linked with poling data from various locations along the Kalamazoo River, including the Morrow Lake Delta/fan area. Additional cores shall be collected to aid in the determination of submerged oil transport rates, depositional patterns, and submerged oil quantification. Target depth for cores shall be 4.5 feet below the water-sediment interface or less if refusal.

Additional sediment cores shall be collected and evaluated as follows, consistent with previously used techniques associated with 2011 submerged oil quantification:

- Hand pushed or driven check-valve sampler (given the shallow depths) shall be used.
- Cores shall be advanced to target depth or refusal. (If target depth is achieved and the recovery is less than 80%, a discrete interval sampler shall be used to obtain recovery greater than 80%. If refusal occurs prior to reaching the target depth and recovery is less than 80%, a second core attempt shall be made, except that at the discretion of the sampler, with concurrence by START/U.S. EPA observer, or by USGS oversight, a second attempt at collection may be omitted in such a case).
- For in-situ bulk density cores, a second check-valve sample shall be collected as a core to a target depth of 5 inches or more, but less than 1 foot. This core shall remain intact and shipped for bulk density and particle size analysis.
- Penetration depth and recovery ratios shall be recorded.
- High water-content sediment-water interface (that may contain submerged oil) shall be recovered.
- In the Morrow Lake Delta, the cores shall penetrate into pre-dam floodplain/channel deposits or to refusal.
- Sediment cores shall be collected from the following locations:
    - Sample locations shall be co-located with poling and velocity transects/profiles wherever possible. Sample locations that are not co-located with these data points shall be noted in the sample log.
    - Morrow Lake fan: transects shall be aligned along a contour from North/South and East/West and in the former river channel (adequate number of locations to allow construction of at least three latitudinal profiles and four longitudinal profiles).
    - 35th Street Bridge to Morrow Lake fan and within the Morrow Lake Delta channels.
    - Other locations in key reaches to be determined in consultation with the SOSG, such as Mill Ponds/Ceresco Dam.

Sediment core sample provisional locations are shown in Attachment C, Figure 4. Final selection of sample locations were coordinated with and approved by the U.S. EPA and USGS.

Sediment cores shall be collected at the following times:

- Fall 2011 (post-recovery and pre-ice formation) – including chemical analysis;
- Spring 2012 (post-flood; pre-recovery) – including chemical analysis for post-spring flood;
- Summer 2012 – visual analyses only;
- Fall 2012 (post-recovery) – including chemical analysis; and/or
- After large flood events (2-year or longer recurrence interval) in 2012. Coring after multiple floods within a 3-month period shall occur only if the difference in recurrence interval between flood events is 5 years or greater. If post-flood cores are supplemental to the scheduled coring events, the type(s) of sample analyses to be performed for collected cores shall be determined in consultation with the SOSG.

On-site core logging shall include the following:

- Stratigraphic logging using the Sediment Logging Standard SOP which includes the Unified Soil Classification System (“USCS”) and United States Department of Agriculture (“USDA”) classification system;
- Color assessment using Munsell Color Charts;
- Visual observation of submerged oil with natural light during characterization and documentation of submerged oil depth and sediment profile layers;
- Depth of oil sheen or globules;
- Use of an UV illuminator for visual observation of submerged oil indicators;
- Standardized sheen test;
- Photographic documentation; and
- Identification of pre-dam (i.e., before Morrow Lake Dam was constructed) and post dam sediment layers in the Morrow Lake fan to calculate sedimentation rates. The sediment cores collected in 2011 and cores to be collected in 2012 will be logged and used to determine if a change in the sedimentation rate has occurred due to submerged oil recovery activities. The flood events that have occurred since July 2010 will also be evaluated in relation to frequency and recurrence interval of past flood events.

During the Fall 2011, Spring 2012, and Fall 2012 coring events, analytical chemistry data shall be obtained from samples secured from the sediment cores. Samples shall be collected from intervals affected by the Enbridge Line 6B Incident based on lithology throughout the entire length of core. Duplicate and matrix- spike/matrix-spike-duplicate pair samples shall be collected at a frequency of 1 each per 20 samples (i.e., 3 QC samples per 20 primary samples). An equipment blank sample shall be collected prior to each coring event, by coring reference material certified to be free of Total Petroleum Hydrocarbons (“TPH”) compounds. Samples shall be analyzed for crude oil related constituents, including TPH (DRO and ORO) and PNAs, using the new revised sample preparation process (10 gram aliquot, new drying method – see (Quality Assurance Project Plan (“QAPP”) for “background” core samples). Samples collected from lithologic intervals potentially affected by the Enbridge Line 6B Incident shall be analyzed for the following:

- TPH consisting of Diesel Range Organics (―DRO”) and Oil Range Organics (―ORO”);
- Polynuclear aromatics (―PNA’s”);
- Trace metals of beryllium, molybdenum, nickel, and vanadium;
- Percent moisture and total organic carbon (―TOC”);
- Bulk density;
- Particle size distribution; and
- Organic matter content (loss on ignition method).

Enbridge shall evaluate the coring results after each sampling event and may modify, with the U.S. EPA’s approval, the number of samples and locations, as appropriate. Modifications to the Work Plan shall be presented to the U.S. EPA for approval.

4.2.5 Sediment Transport

To determine how submerged oil and oil-containing sediment may be transported in various geomorphic settings, additional information shall be collected and evaluated. The existing data sets consist of turbidity measurements, sediment bed-material types (poling data, cores), and velocity measurements collected over the course of the project to date. Anecdotal evidence suggests that submerged oil migrates in association with fine-grained bedload and/or suspended sediment.

This evidence also suggests that the migration is dependent on flow conditions, affected by temperature, and agitation from oil recovery operations. Increased sediment transport also takes place during runoff events (e.g., rain events), but a substantial part of annual load presumably occurs during low-flow conditions (cf. 36-43 percent for Paw Paw River near Paw Paw (USGS 04102320), 1980-82, draining 195 mi^2).

To evaluate how submerged oil is transported in various geomorphic settings and the mass of submerged oil transported in suspended and/or bed-load components, Enbridge shall collect the following data to allow for a better understanding of the issues:

- Time-integrated suspended sediment sampling, which shall occur downstream of agitation/recovery areas and silt curtains. Enbridge shall use Walling suspended sediment traps (Phillips et al., 2000) at the following locations and in accordance with the following parameters:
    - Two traps placed upstream of the confluence of Talmadge Creek and the Kalamazoo River to obtain background suspended sediment samples.
    - Morrow Lake: downstream and in the vicinity of E4.5 control point. Three traps shall be placed in 2011 depositional areas.
    - Seven traps shall be located on an approximate North-South transect across the Morrow Lake fan in 2011 depositional areas. The traps shall be placed and co-located at poling locations.
    - Downstream of Dickman Road culverts and upstream of the Kalamazoo River Dam: A sampler will be placed mid-channel upstream of the 20th Street Bridge. Locations were field checked to verify that it is an appropriate location for sampling suspended sediment. Following the sampling event in Fall 2011, the SOSG will review the data

  and determine if locations are appropriate/representative or if other locations shall be selected.

- Ceresco impoundment: Transects shall be located immediately upstream of the dam, in the thalweg and adjacent to the thalweg on each side, and downstream of the former rail road trestle (two to three locations, equally spaced along a transverse transect).
- Traps have been placed using 2 rebar per location. The length of rebar is selected based on the water depth and soft sediment thickness. The rebar is driven into the sediment bed and the samplers are placed over the rebar using polyvinyl chloride (―PVC”) sleeves. Two ropes are used to set the sampler at the appropriate depth and the ropes are tied off to the rebar. Fluorescent painted PVC rope hangers and a buoy mark the location. Locations set in deeper water (>2.5 feet) shall be installed with two Walling traps to obtain a near streambed sample and a near water surface sample.
- During submerged oil recovery, Enbridge shall check the traps monthly, after storm events, immediately following oil recovery operations, and at other times as directed by the U.S. EPA. Sampling shall be conducted once per month or when there is adequate volume in a single trap or for a composite sample from a suspended sediment location (each location consists of one or two traps). The UV test will be used on each trap or composite sample to determine the presence or absence of submerged oil.
- After oil recovery operations are complete for the field season, Enbridge shall check and the traps once a month and at other times as directed by the U.S. EPA. The Walling samplers shall be removed before freeze up or remain in place over the winter, if conditions allow. This decision shall be made in consultation with the SOSG.
- In Spring 2012, the Walling samplers shall be installed as soon as safe work conditions allow. For 2012, the Walling samplers shall be installed, monitored and sampled in the same manner as 2011, except that during periods of high flow, sediment samples may need to be retrieved more frequently than monthly.
- Assuming adequate volume is collected, sediment chemistry data shall be obtained from samples secured from the Walling suspended sediment traps and shall be analyzed for following parameters:
  - TPH (DRO, ORO);
  - PNA’s;
  - Trace metals of beryllium, molybdenum, nickel, and vanadium;
  - Percent moisture and TOC;
  - Particle size distribution; and
  - Organic matter content (loss on ignition method).

If insufficient sample is obtained from a trap, the following guidelines to prioritize sample analysis will be utilized. Alternatively, in consultation with the SOSG, traps from a single location could be composited to increase the amount of material for a sample, or re-install the trap to obtain additional sample for sampling at a later date. Sample prioritization will be as follows when insufficient sample quantity precludes all analyses:

1. TPH (DRO, ORO)
2. PNAs
3. TOC
4. Percent moisture
5. Particle size distribution
6. Trace metals of beryllium, molybdenum, nickel, and vanadium
7. Organic matter content

The proposed suspended sediment sample locations are shown in Attachment C, Figure 5.

4.2.6 Data Results

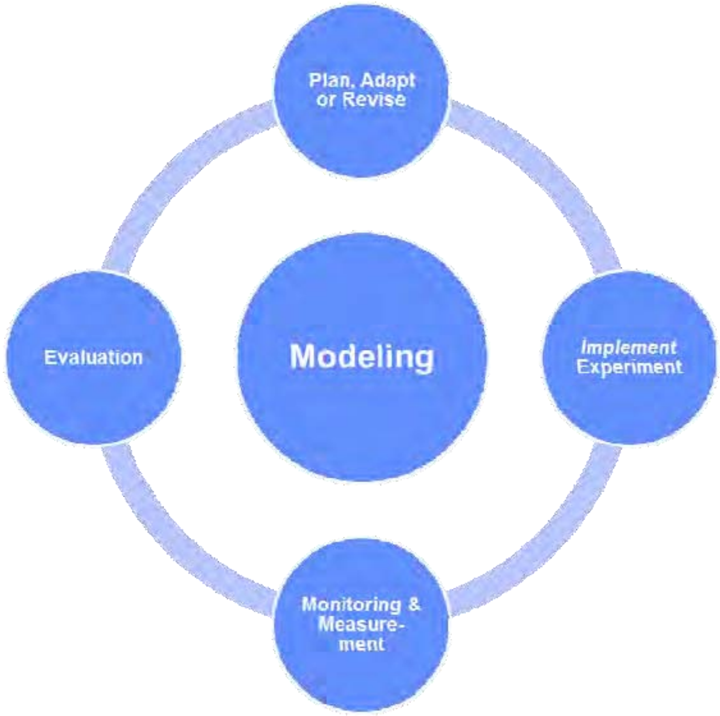
Enbridge shall provide the U.S. EPA, MDEQ, and USGS with the results of all data from the hydrodynamic assessment in spreadsheets, maps, model runs, and/or word processing formats. Also included shall be other related data for the following parameters/items: water temperature, turbidity, sediment temperature, water velocity, surface water elevation, depth to soft sediment, soft sediment thickness, depth to hardpan, core logging information, all other surface water field parameter data collected to date, analytical data, river discharge rates, river stage, and sediment curtain configurations from project inception (Geographical Information System format). Enbridge shall also provide location information (e.g., global positioning system data, latitude/longitude). The evaluation and presentation of the data shall be provided to the U.S. EPA within 30 days after field work is complete.

4.3 Hydrodynamic Modeling Strategy and Operational Plans

4.3.1 Introduction

A physical-process model of an environmental system can be a valuable resource for testing the present understanding of a complex system, revealing gaps in knowledge and areas where better detail is needed to provide useful predictions of future scenario outcomes or the effects of system alterations. Such applications of modeling are particularly valued to support several stages of the adaptive management cycle (Figure 4.3.1). A process model can suggest strategies for attaining environmental management goals that planners then formulate as management experiments to be implemented for real-world testing. The model can explore where and when to monitor the system to most sensitively gather metrics on how well the experiment is working. Monitoring data shall allow updates to the model to continue to advance our understanding of the river and make informed management decisions pertaining to the location and recovery of submerged oil.

Figure 4.3.1 The Adaptive Management Cycle of Experimentation and Iterative Learning



For an inland riverine ecosystem where sediment-associated contaminant transport is of principal concern, critical data for understanding submerged-oil entrainment, transport, deposition, and recovery include predicted water-surface elevations, velocity magnitudes, flow directions, and bed-shear stresses for a broad range of hydrologic conditions up to the 50-year flood discharge.

4.3.2 Purpose and Scope

This Work Plan describes tasks and procedures that shall achieve the following objectives of the hydrodynamic modeling study of the fate and transport of submerged oil from the Enbridge Line 6B Incident:

1. Successfully calibrate a 3-dimensional hydrodynamic model for unsteady, open-channel flow, capable of simulating with useful accuracy the spatial and temporal variations in river velocities, bed-shear stresses, and consequent sediment entrainment, transport, and deposition of sediment-oil mixtures;
2. Gain improved understanding of the transport of submerged oil; specifically, by simulation of the variables in objective 1 resulting from various regimes of streamflow conditions that include flows ranging from low flows of frequent occurrence to flood flows having
   a. an annual exceedance probability (―AEP") of 0.02 (50-year recurrence interval);
3. Simulate a variety of scenarios for containment, collection, and recovery of submerged oil-laden sediment, and for proposed sediment collection structures and future boom arrangements; and

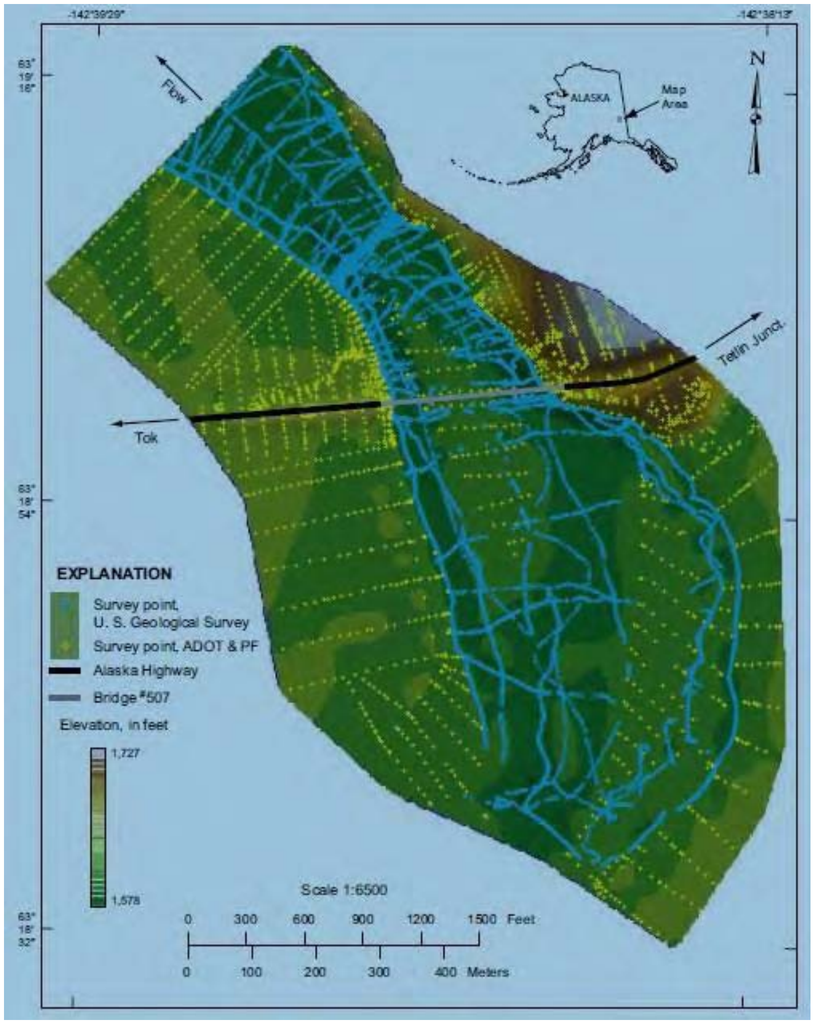
4. Document the post submerged oil recovery findings of this hydrodynamic model to assist in the long term planning, design, implementation, monitoring, and evaluation of future river management methods.

The model design will be a collaborative process with SOSG involvement at all stages of model development.

The model domain shall extend from the USGS stream flow gauging station on the Kalamazoo River at Marshall (station ID 04103500) at the upstream end, to Morrow Lake Dam on the downstream end. Laterally, the model domain shall include all areas inundated by the peak flow having a 50-year recurrence interval (0.02 AEP). The model shall be calibrated to river stage and velocity measurements, and sediment transport measurements. The data used for streamflow and sediment discharge rates will represent the present hydroclimatic period, recognized to have begun in North America during the early 1970s (cf. Wolock and McCabe, 1999; Milly et al., 2005; McCabe and Wolock, 2010). Oil-containing sediment collection areas and techniques to be simulated shall be identified in consultation with the SOSG, shall be approved by the U.S. EPA prior to simulation, and shall include such techniques as in-stream silt curtains, booms of various types, and other barriers constructed of natural or artificial materials with a variety of permeability and pore sizes. Submerged oil recovery scenarios to be simulated shall be planned in consultation with the SOSG, shall be approved by the U.S. EPA prior to simulation, and shall include such techniques as shallow agitation (~0.5 ft), deep agitation (> 1.5 ft), and low-disturbance alternatives. Early products of the modeling study shall include metadata and maps of the digital elevation model comprising bathymetric and terrain models of the respective sectors of the model domain (e.g., see Figure 4.3.2); graphs showing the goodness-of-fit between measured and simulated values of the calibration targets; and graphs illustrating the sensitivity of simulation results to incremental changes in the calibration parameters. The model shall be verified with additional data collected in 2012 as part of this Work Plan and/or at such time when the obligations under the U.S. EPA Order have been met. The modeling strategy is an iterative process incorporating the four main stages of the adaptive management cycle:

- Plan, adapt or revise;
- Implement experiment;
- Monitoring and measurement; and
- Evaluation.

Figure 4.3.2 -- Example map of digital elevation model showing points where bathymetric and terrain data were collected (from Conaway and Moran, 2004).



4.3.3 Study Area Description

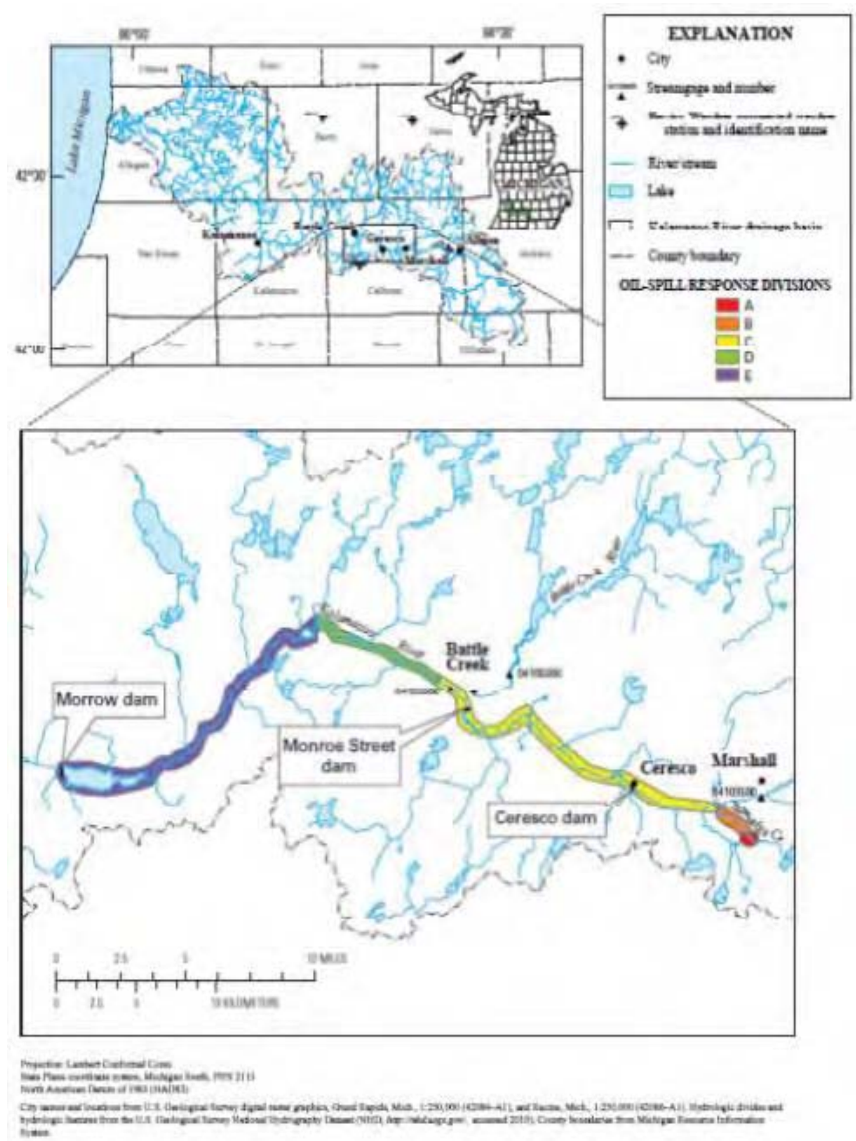
Because of the need to estimate streamflow from ungauged tributaries, including Talmadge Creek, a description of the study area's salient characteristics is critical to the hydrodynamic modeling study. The streamflow of Talmadge Creek and other ungauged tributary streams shall be estimated at each model time increment. Among the longer tributaries (> 4 mile long) downstream from Talmadge are Bear, Minges-Harper, Battle, Wabascon, Sevenmile, Augusta, and Gull Creeks. The modeling study area includes all of the 38 mile of the Kalamazoo River affected by the 2010 oil spill, ending at Morrow Lake Dam, which is about 80 mile upstream from Lake Michigan (Figure 4.3.3). Morrow Lake Dam also is designated as the upstream boundary of the binationally recognized Kalamazoo River Area of Concern (1987 amendment to the 1978 Great Lakes Water Quality Agreement; Kalamazoo River Public Advisory Council, 2000). By previous convention, the point where released crude oil entered Talmadge Creek has been designated to have a river-wise downstream mile-post coordinate (―MP") of 0 mile and Morrow Lake Dam is located near MP 40.

Warm to hot summers and severe winters characterize the temperature regime of the humid continental climate in the study area. At a representative climate station (Battle Creek 5 NW) normal monthly mean temperatures range from 23.1° F in January to 71.0° F in July (National Climatic Data Center, 2002). Normal precipitation near Battle Creek is 35.15 inch. and monthly means range between 2.4 and 3.6 inch. for all months except January (1.7 inch), February (1.5 inch), and September (3.9 inch). Thus there is no pronounced dry season.

The study area lies wholly within the drift plains ecological region of Southern Michigan and Northern Indiana (Omernik, 1987; U.S. Environmental Protection Agency, 2007). The Kalamazoo River near the study area flows through an alluvial valley eroded into glacial deposits and, locally, bedrock units including the Marshall Sandstone and Coldwater Shale (Dorr and Eschman, 1970; WMU, 1981). The river drains a basin characterized by well-drained soils developed on relatively permeable glacial deposits having developable yields of groundwater (Bent, 1971). Consequently, streamflow of the Kalamazoo River largely is groundwater fed. Additional description of the geology and hydrogeologic framework of the study area is provided in Enbridge (2010, p. 11-12).

Within the study area, the Kalamazoo River reaches are mostly sinuous and single-threaded, but numerous islands, bars, and chutes also occur. As a result of historical dam building projects, three impoundments have resulted in upstream deposition of sediment, channel aggradation, and braided delta formation where width is not constrained. In addition to the impounded slackwater, the Kalamazoo River includes a variety of other sluggish backwater and side channels, flood chutes, abandoned or intermittently abandoned oxbows, and floodplain wetlands that are hydraulically connected to the main channel and that have had repeated submerged oil recovery efforts. Many depositional areas are located along channel margins and banks, where the river channel naturally widens. Some are the result of large wood debris and overhanging trees and branches. Lastly, during 2011 low flow, submerged oil accumulated in areas that were scoured during flooding associated with the initial oil spill. Some of these have been sites of recurring submerged-oil deposition (e.g., ―the oxbow” at MP 21.5). Existing observations of depth, velocity, and sheen intensity generally are associated with point data collection (poling method) during safe-boating conditions (not flood flows) and have been inadequate to develop complete, detailed, and accurate predictive capabilities with regard to objectives 2 through 4 as enumerated for this study. Hydraulic flow fields observed during low-flow conditions can be either dampened or intensified when flow rates are higher; consequently, existing data for low-flow hydraulics are an insufficient basis for reliable development of either river-structure design or sediment transport studies (cf. Conaway and Moran, 2004). The modeling work described in this Work Plan provides an expanded scope and methods to obtain information about the riverine system during low- and high-flow conditions to allow the study objectives to be fully addressed.

Figure 4.3.3 -- Location of Kalamazoo River study area.



4.3.4 Existing Hydraulic Models of the Kalamazoo River in the Study Area

USGS model: Marshall-to-Battle Creek. Heavy rainfall in the study area during the 3 days preceding the Enbridge Line 6B Incident produced flood conditions that heightened environmental effects of the spill by transporting fresh, buoyant crude into many low-lying areas. The flood peak had an approximate annual exceedance probability of 4 percent on the Kalamazoo River (Hoard et al. 2010). When post-flood attention focused on characterizing the extent of the spill, the USGS was tasked with constructing a hydraulic model using the U.S. Army Corps of Engineers' Hydrologic Engineering Center River Analysis System (―HEC-RAS") (U.S. Army Corps of Engineers, 2002).

USGS crews surveyed stream-channel and bridge geometry, providing data for a 15-mile stretch of the Kalamazoo River from Marshall to Battle Creek to assist with remediation of flood-plain sediment and vegetation affected by the spill. Enbridge shall consider the published flood elevations from Hoard et al. (2010) as an independent source of water-level validation targets for the present study. Also Enbridge shall consider the channel bathymetric data for cross-sections surveyed in August 2010 by USGS crews, using hydroacoustic instruments for depths and differential GPS receivers to record horizontal position. Water-surface elevations were surveyed at 19 locations along the modeled reach and used to calibrate the HEC-RAS model (Hoard et al. 2010).

AECOM model: Battle Creek-to-Morrow Lake Dam. Subsequently, Enbridge (AECOM, written communication, June 2011) in response to a U.S. EPA letter (dated April 14, 2011) commissioned the expansion of the USGS model from Battle Creek to Morrow Lake Dam; the simulation of flood peaks with recurrence intervals of 10, 25, 50, and 100 years; and the July 25, 2010, flood event. The purpose of the expanded modeling study was to help identify the inundated area at the time of the spill.

New LiDAR data were collected during April 2011 to provide a topographic model in support of this study. Also, channel transects were surveyed at spacing of 2,000 feet or less throughout the area of expanded study and at all bridge crossings of the Kalamazoo River from Battle Creek to Morrow Lake Dam. In addition to transects, a sonar-derived bathymetric map of the bottom of Morrow Lake was constructed. All 8 bridge crossings in the expanded reach were surveyed and measured to describe the location and thickness of each pier, total opening size, and bridge deck elevation.

Additionally, high water marks (―HWMs") were identified and their elevation measured using hand-held GPS receivers. Many of these HWMs were oil stain rings on tree trunks, left by the July 2010 flood ongoing at the time of the Enbridge Line 6B Incident.

4.3.5 Data Collection

Multi-dimensional hydrodynamic models require considerably more hydrologic, topographic, bathymetric, and hydraulic data collection than do one-dimensional models. For this study, advanced hydraulic, bathymetric, and topographic surveying instrumentation shall be used for collection of needed data efficiently and with reliable accuracy. Discharge measurements and/or water-level data shall be obtained from hydrologic data systems of the USGS and Enbridge for all stream gauges actively operating during the study period (Table 4.3.1). Miscellaneous discharge measurements on ungauged tributaries have been made by the USGS and MDEQ and Michigan Department of Natural Resources; these shall be compiled for potential use in calibrating or estimating contributions of tributaries to the main stem's discharge. The specific method selected for estimation of streamflow of each ungauged tributary shall be described in detail by Enbridge, and is expected to comprise use of available streamflow and weather data with either a numerical rainfall-runoff modeling approach to estimate the streamflow at the mouth of each ungauged tributary, and/or a statistical modeling approach based on basin characteristics and streamflow records of gauged streams paired with each ungauged tributary; possibly with varying approaches among the various tributaries; and will include methods for evaluating accuracy of the estimates and their contribution to the overall uncertainty of the hydrodynamic model.

All USGS gauging stations have hourly time-series data for water level and discharge. Enbridge's 10 stage-only gauges have only once daily observations of water level, and were operated seasonally, lacking observations for the winter period. All water levels shall be compiled as altitudes referenced to the National Geodetic Vertical Datum (―NGVD”) of 1988, and shall provide either boundary conditions for model runs, or calibration targets.

Table 4.3.1 Stream flow-gauging stations within or adjacent to the study area, with daily streamflow data inventory through October 2011.

Agency	**Station identifier**	**Station name**	**Start date**	**End date**	**Count of daily values**
USGS	04103500	Kalamazoo River at Marshall	Oct. 1948	Oct. 2011	15,914
USGS	04105000	Battle Creek at Battle Creek	Oct. 1930	Oct. 2011	28,988
USGS	04105500	Kalamazoo River near Battle Creek	July 1937	Oct. 2011	27,124
USGS	04105700	Augusta Creek near Augusta	Oct. 1964	Oct. 2011	17,196
USGS	04105800	Gull Creek at 37th ST near	Oct.	Feb.	3,065
		Galesburg	1964	1973	
USGS	04106000	Kalamazoo River at Comstock	Apr. 1931	Oct. 2011	27,219
Enbridge	MP 2.25	Kalamazoo River at 15 Mile Rd	Apr. 2011	Oct. 2011	155
Enbridge	MP 5.25	Impounded Kalamazoo River near Ceresco	Apr. 2011	Oct. 2011	161
Enbridge	MP 10.0	Kalamazoo River near boat launch C-3.2	Apr. 2011	Oct. 2011	163
Enbridge	MP 15.0	Kalamazoo River at South Mill Pond, Battle Creek	Apr. 2011	Oct. 2011	151
Enbridge	MP 18.75	Kalamazoo River at S Bedford Rd, Springfield	Apr. 2011	Oct. 2011	162
Enbridge	MP 21.5	Kalamazoo River at Custer Drive	Apr. 2011	Oct. 2011	152
Enbridge	MP 27.0	Kalamazoo River at Shady Bend near Augusta	Apr. 2011	Oct. 2011	157
Enbridge	MP 30.0	Kalamazoo River at Fort Custer RA near Augusta	Apr. 2011	Oct. 2011	158
Enbridge	MP 35.0	Kalamazoo River at Galesburg	Apr. 2011	Oct. 2011	143
Enbridge	MP 38.0	Morrow Lake near Galesburg	Apr. 2011	Oct. 2011	158

The existing data used to inform the hydrodynamic model includes the HEC-RAS cross-sections, longitudinal profile, water depths at specific stream gauge datum, Real Time Kinematic –Global Positioning System(―RTK-GPS") x, y, and z coordinates at poling locations, stream bed particle size and bulk density data. This data is used in the model setup to establish the characteristics of the river.

One of the parameters of the hydrodynamic model is the bathymetry of the river channel. In 2010, single and multi-beam sonar were evaluated to map the bathymetry of the Kalamazoo River. The shallow water depth across most of the river prohibited using these tools. Single beam bathymetry was completed for Morrow Lake and the western half of the Morrow Lake Delta. Multi-beam sonar was used on a portion of the area upstream of Ceresco Dam. Poling is used to determine the water depth and the RTK GPS reading provides x, y, and z coordinates which include top of water and sediment bed elevations. This altitude elevation data can be used in conjunction with the water depth to determine the top of sediment elevation. The top of sediment elevation collected at thousands of poling points is the basis for a bathymetric map.

The SOSG shall review the existing bathymetry data developed from the poling and sonar activities and the corresponding inputs to the hydrodynamic model. The SOSG shall identify and evaluate data gaps to determine their effect on the accuracy of the model. Additional poling may be conducted or bathymetric mapping (echo sounder, single beam or multi-beam sonar) may be used to fill the data gaps. The SOSG will ensure that all data collected is adequate to achieve the goals and objectives of the model and will identify data quality objectives.

Data collected in 2011 to setup and inform the model includes detailed poling cross-sections at specific HEC-RAS cross-sections, particle size and bulk density data from sediment cores, velocity monitoring, suspended sediment samples, and cohesion/erodibility data. The detailed poling cross-sections were completed at 23 cross-sections and water depth data was collected every 10 feet on a transect perpendicular to stream flow. Particle size and bulk density data was collected at 110 sediment core locations from the Kalamazoo River, Morrow Lake Delta, and Morrow Lake fan. Velocity data was collected with an ADCP at single point and transect locations. The velocity data is collected in 3D to capture the detail of the water velocity. The velocity profile horizontally and vertically has a direct relationship to amount and type of sediment transport. The suspended sediment data will be used to determine if and/or how much submerged oil is moving in suspension at different depths in the water column. The cohesion/erodibility data provides the model with specific values for the river sediment cohesiveness, critical shear stress, and erodibility.

The SOSG shall review existing data sets to identify data gaps. The methods needed to fill the data gaps shall be determined by the SOSG. The purpose of the data and the methods used to collect the data will be clearly communicated to the field personnel.

Terrain data for areas outside the channel and for sub-aerially exposed parts of the channel may be collected on a different day than hydraulic and bathymetric data are collected for each reach; however, the same Quality Assurance (―QA") procedure for opening and closing observations at a Survey Control Station (―SCS") shall be followed for terrain surveys as for bathymetric surveys. Any instrument substitutions shall be approved by the U.S. EPA in advance of data collection.

All bathymetric and terrain data shall be compiled as altitudes referenced to the current NGVD (NGVD 1988). Horizontal coordinates shall be referenced to Michigan's State Plane Coordinate

System, as specified elsewhere herein. All coordinates shall be expressed in international foot (1 international foot = 0.3048 meters).

Table 4.3.2 [Example of] Location of survey control stations and daily water-surface elevations during bathymetric survey, Tanana River near Tok, Alaska (from Conaway and Moran, 2004).

[WSELEV, water-surface elevation]

Location (Alaska State Plane zone 2, NAD 83, NAVD 88 survey feet)			
Description	**Easting**	**Northing**	**Elevation**
ADOT&PF Control point 1	1533071.81	3404825.83	1,627.08
ADOT&PF Control point 2	1533711.52	3404928.48	1,625.14
ADOT&PF Control point 3	1534655.68	3405031.25	1,643.88
ADOT&PF Control point 4	1534942.47	3404923.68	1,672.00
08-07-02 Starting WSELEV	1533724.71	3405027.71	1,609.87
08-08-02 Starting WSELEV			1,610.09
08-08-02 closing WSELEV			1,610.24
08-09-02 Starting WSELEV			1,610.41
08-09-02 closing WSELEV			1,610.48

Results from the bathymetric and terrain surveys shall be merged to produce a digital elevation model with sufficient data density and adequate spatial distribution that allows development of an accurate and stable, high-resolution hydrodynamic model. The acceptable standard error of the digital elevation model (―DEM”) shall be determined by the SOSG.

4.3.6 Hydrodynamic Model Geometry, Parameterization, and Calibration

Software selection shall support the modeling of as many of the physical river-process mechanics as is practical given present state-of-the-science and practical considerations of needs for data quality, timeliness, and cost-effectiveness. The initial geometry of the model shall be defined using the DEM that merges results of the bathymetric and terrain surveys. Areas of ineffective flow (near shoreline where obstructed or where channel curvature creates secondary flow patterns) shall be identified where possible using velocity data obtained from ADCP or ADVM measurement sections. The model domain shall extend from sufficiently near the USGS streamflow-gauging station on the Kalamazoo River at Marshall (station ID 04103500) to assume its streamflow record as the inflow at the upstream end, to Morrow Lake Dam on the downstream end. Laterally, the model domain shall include all areas inundated by the peak flow having a 50-year recurrence interval (0.02 AEP).

Mesh configuration shall be summarized in tabular form (e.g., see Table 4.3.3) and shown for selected parts of the model domain in Figure 4.3.3. Results from surveyed or as-built engineering data provided for bridges and dams shall be incorporated into the final mesh prior to any model runs.

4.3.6.1 Model parameterization

Some model parameters account for energy losses associated with channel roughness and those associated with expansions and contractions of the hydraulic cross-sectional area. Overbank areas of channel cross-sections shall be assigned time-invariant roughness values, but main channel areas shall have bed form roughness values that vary as the dynamic interaction between hydraulics and sediment produces varying bed form states during the course of a simulation run. Expansion and contraction coefficients initially shall be set to 0.1 and 0.3, respectively, for all cross-sections in the model domain.

Other model parameters relate to sediment entrainment, transport, and deposition. Among these shall be characteristic metrics of the particle-size distribution (―PSD”), density and cohesion of the oil-sediment mixture, critical shear stress for entrainment, metrics of bank erodibility, and characteristic settling velocity. Settings for fixed-value parameters and boundary conditions shall be listed in tabular format (e.g., see Table 4.3.3). Water temperature and viscosity also are important considerations for sediment transport and settling, but time-series data from water- temperature monitoring shall be the basis for these.

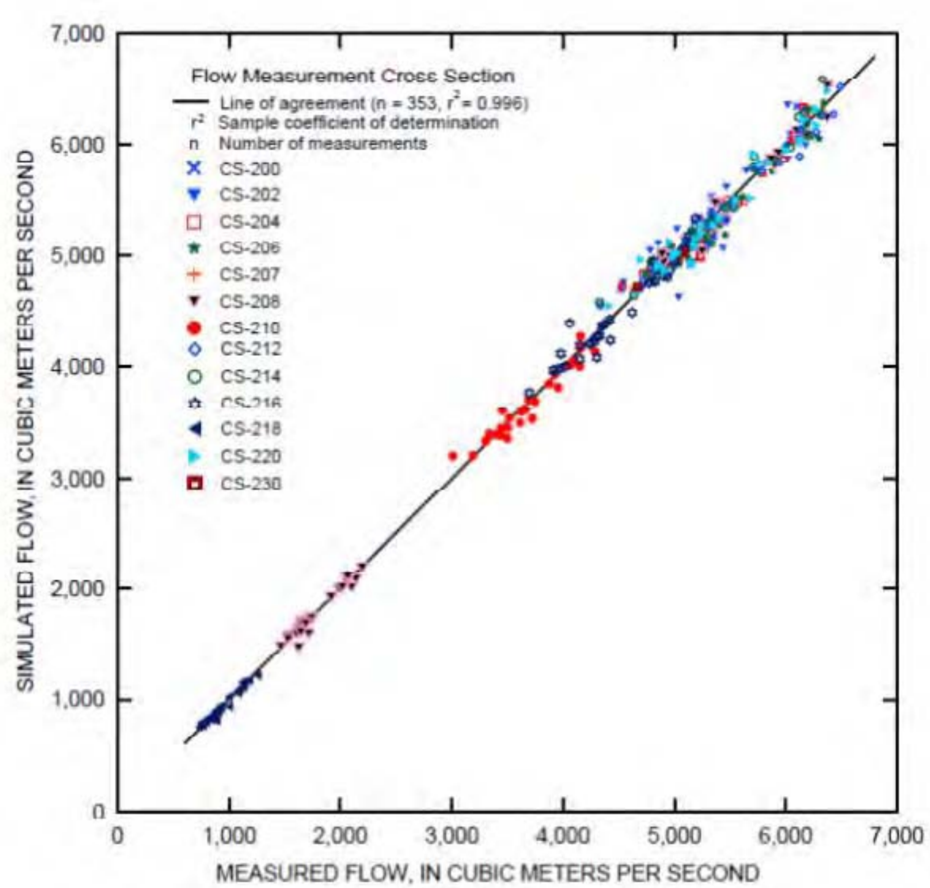
Hourly water-level data from the Kalamazoo River at Marshall gauging station shall serve as the upstream boundary condition for model runs. Water level data for Morrow Lake from a stage-only gauge (operated by Enbridge) shall provide the downstream boundary condition for model runs, whenever applicable. If data are available from the operator of Morrow Lake Dam, the discharged outflow from Morrow Lake would provide an additional check and downstream condition. Flow augmentations and lateral fluxes for tributary mouths and streambed seepage, respectively, shall be either estimated from tributary streamflow gauging stations (Table 4.3.1) or hydrologic models, as described herein.

4.3.6.2 Model calibration

Boundary conditions and model parameters shall be calibrated to data collected during the hydraulic surveys and available or published data from the USGS, State agencies, Enbridge, or other institutions. The drag coefficient for the channel plan form shall be calibrated through an iterative process where predicted water-surface elevations and current velocity magnitudes are compared to measured values. The lateral eddy viscosity also shall be calibrated though an iterative process and predicted velocity vectors shall be compared to those measured by the ADCP or ADVM. Available data for selected high-water marks (―HWMs”) of known peak flows shall be compared to predicted water levels for similar, simulated upper-quartile and larger discharges. Other HWMs and published data for flood-inundation simulations of known peak flows may be used either as calibration or validation targets for this hydrodynamic model. If published data from previous simulations are used, differences in model construction and assumptions shall be noted and their effects on comparisons shall be discussed. Graphs shall be prepared showing the relation between measured and simulated values for the calibration targets. Summary statistical metrics shall be calculated to quantify the goodness-of-fit for the calibrated model.

Recorded or measured streamflow at intermediate and downstream sites shall be compared with simulated streamflows to estimate additional metrics for the calibration goodness-of-fit. An example graph showing results of this type for a model of the St. Clair River, Michigan-Ontario, is shown in Figure 4.3.4 (from Holtschlag and Hoard, 2009).

Figure 4.3.4 -- Relation between simulated flow and flow measured on the St. Clair River from 1996 to 2007 (from
Holtschlag and Hoard, 2009)



4.3.6.3 Sensitivity Testing

Once a final calibrated model is obtained, Enbridge shall conduct sensitivity testing to evaluate the uncertainty of simulation results related to uncertainty in model-calibration parameters and other input parameters. Adjusted parameter settings shall be increased and decreased from their final settings in the following relative increments: 2, 5, 10, 15, 20, and 25 percent of the final setting used for the calibrated model. For each incrementally adjusted setting, a simulation run shall be used to determine the resultant effect on model sensitivity targets: water levels, velocities, discharge, suspended-sediment concentrations and loads, scour volume, and depositional volume. Effect on each target shall be expressed as a percentage departure from its value in the final, calibrated model.

Table 4.3.3 [Example of] Model parameters and boundary conditions used for simulations of the calibration discharge and the discharge having a 50-year recurrence interval at station Kalamazoo River at xx (after Conaway and Moran, 2004).

Model parameter or boundary condition	**Calibration discharge**	**50-year flood discharge**
Number of grid cells	100,000	200,000
Mesh spacing in stream-wise and transverse directions, in feet	5	5
Channel form drag coefficient	.004	.004
Bed form drag coefficient	.008	.006
Grain roughness coefficient	.020	.020
Overbank drag coefficient	.12	.12
Expansion coefficient	0.1	0.1
Contraction coefficient	0.3	0.3
Lateral eddy	4.3	4.3
viscosity, in ft2/s		
Discharge, in ft3/s	3,500	6,000
Initial water-surface elevation at downstream end, in feet	xx.xx	yy.yy
Stream gradient, in ft/ft	.00011	.00013
Sediment median size, in mm	.35	.35
Sediment d84 size, in mm	xx.x	yy.y
Density of oil-sediment mixture	x.xxxx	y.yyyy
Cohesion of oil-sediment mixture	x.xx	y.yy
Critical bed-shear stress for sediment entrainment	x.xx	y.yy
Bank shear strength	x.xx	y.yy
Bank tensile strength from roots	x.xx	y.yy
Characteristic settling velocity	x.xx	y.yy

4.3.7 Hydrodynamic Simulations Using Calibrated Model

Progress on model development shall proceed from the planning stages forward in a collaborative mode, with frequent, regular consultation with the SOSG, very similar to what was begun with the weekly calls for the hydrodynamic assessment work group. The final, calibrated model shall be used for testing scenarios of various management strategies. All scenarios shall be compared with a baseline simulation that contains no changes from existing conditions (Fall 2011 [specific date to be determined in consultation with the U.S. EPA and USGS]) in terms of geometry, sediment size distribution, sediment loading from upstream, or river management; this baseline simulation shall be referred to as the Fall 2011 baseline, and shall provide the capabilities indicated in Objective 1, thus demonstrating attainment of that purpose of the study. The Fall 2011 baseline results shall themselves be valuable for identifying velocity patterns and indicated sediment-depositional areas that correspond to a range of possible stream flow events. However, in the context of adaptive management many other benefits can be provided by simulating contemplated changes or additions to the suite of river management practices implemented in the study area.

Enbridge shall achieve study Objective 2 by simulation of a variety of streamflow conditions that represent the present flow regime, including flows in both below-median quartile of a flow- duration table for the Kalamazoo River, each above-median decile of a flow-duration table for the Kalamazoo River in the study area, and high-flow events that contain peak streamflows with return intervals of 1.5, 2, 5, 10, 25, and 50 years. Objective 3 shall be achieved through simulation of specific system scenarios, with the set of scenarios corresponding to varying combinations of streamflow, sediment inputs, oil-sediment temperature, and river-management practices and installations. The following Table 4.3.4 lists some of the scenarios envisioned for testing by use of the calibrated model with, as examples, hypothetical additions of dikes or chevrons to the channel structures, changes in channel roughness caused by introduction of large woody debris (―LWD”), or construction of sediment collection areas. Selection of actual scenarios shall be made in consultation with the SOSG.

Enbridge shall achieve Objective 4 by transferring the model to a regulatory agency at the federal, state, or local level when submerged oil recovery is complete. Findings from the post recovery modeling study shall be communicated to officials working at all phases of river management.

Those planning or designing long term river-management strategies and experiments need to suggest scenarios to be modeled, and modelers shall provide results and interpretations to the planners/designers that inform adjustments to the implementation plans for each experiment. Predictive simulations using the final implementation plan for a river-management experiment shall indicate where deposition and other changes in channel geometry are expected to be the largest, and where sediment transport rates are likely to be at maximum. Those locations become the priority monitoring targets for that experiment. During an extended experiment and after its completion, the collected monitoring data shall be used by modelers to construct an updated version of the hydrodynamic model that represents conditions at the respective time. The updated version shall be re-calibrated using the monitoring data, and used to evaluate the ―how?” and ―why?” behind the experimental outcomes.

Clearly, achieving the goal of science impact on the river management process shall be an iterative and sometimes lengthy, demanding process. But finding the optimal long-term solutions for river management requires prudent application of the modeling results to achieve Objective 4 of the study.

4.3.8 Timeline for Hydrodynamic Simulations [Example]

Existing data and hydrodynamic assessment data collected during the Fall 2011 field work for import into the hydrodynamic model included HEC-RAS model cross-sections, longitudinal profile, water depths, stream bed particle size, poling downstream of Morrow Lake Dam, LSR poling, sediment core collection, velocity monitoring, suspended sediment samples, detailed poling cross-sections, and the cohesion/erodibility test. The schedule provided includes the existing and assessment data availability to upload to the model. The dates shown are when the data were available for upload. The Summer 2011 reference means the data were available before the hydrodynamic model scope was defined.

- Single Beam Bathymetry of Morrow Lake — Summer 2011
- Multi-Beam Bathymetry upstream of Ceresco Dam — Summer 2011
- HEC-RAS cross-sections — Summer 2011
- Longitudinal profile — Summer 2011
- Water depths at specific stream gauge datum — Summer 2011
- Stream bed particle size — Summer 2011
- Bulk Density data — Summer 2011
- Poling downstream of Morrow Lake Dam — October 2011
- Late Summer Reassessment poling — November 2011
- Detailed poling cross-sections — November 2011
- Sediment core collection — December 2011
- Velocity monitoring — December 2011
- Suspended sediment samples — December 2011
- Cohesion/erodibility data — December 2011

The phases of the hydrodynamic model are grid setup, configuration for flow and velocity, analysis of sediment and cohesion data, complete model configuration including sediment processes, model calibration, preliminary and baseline model scenarios, and modeling of various flow events and changes in river conditions. The model milestones are provided below.

- Provide bathymetry and terrain data to the SOSG — December 9, 2011.
- Model Grid setup and QC — December 16, 2011
- Configuration for flow and velocity — December 30, 2011
- Analysis of sediment samples and cohesion data — January 13, 2012
- Complete configuration including sediment processes — January 27, 2012
- Model calibration — February 10, 2012

- Preliminary and baseline model scenarios February 24, 2012
- Sensitivity Testing February 24, 2012
- Develop Scenarios/Various Simulations March 23, 2012
- Completion of Simulations March 23, 2012
- Run Modified Scenarios April 6, 2012

A schedule will be developed with the SOSG to evaluate the draft component pieces of the model prior to the model milestone dates listed above.

Scenarios representing different flow events and structural control features shall be selected through consultations among Enbridge, the U.S. EPA, MDEQ, and with other stakeholder input. The results of the iterative scenarios will be reviewed by the SOSG and will allow review and adaptive management discussions, and runs of modified scenarios. It is expected that adherence to this timeline shall allow final planning, coordination, logistics, and staging for experiments to be completed by the end of March 2012. A report summarizing the simulations of target stream flow conditions and management scenarios shall be prepared and submitted by April 13, 2012.

Table 4.3.4 Partial listing of management scenarios to be simulated and compared with the Fall 2011 Baseline simulation.

Question addressed	**Stream flow conditions**	**Sediment conditions**	**Temperature conditions**	**River-management practices**	**Range of dates (if using a recorded flow scenario)**
Risk of having sediment transport over Morrow Lake Dam by a frequent winter high-flow pulse	Recorded high-flow event with peak discharge = 3,260 cfs at upstream gauge	Steady input concentration of 100 mg/L at 35th Street Bridge	Cold – 2 to 4 deg. C. for water; 4 to 7 deg. C. for sediment-oil mixture	No booms, curtains, dikes, chevrons, or sediment traps except existing Morrow Lake Dam	Jan. 2008 [specific range of days to be included to be determined in consultation with U.S. EPA and USGS]
Risk of sediment remobilization by E4.5 double-chevron removal	Uniform flow at above-median rate for Fall season; i.e., discharge = 870 cfs at upstream gauge [	Initial, instantaneous concentration of 100 mg/L spread over 40,000 ft^2 area immediately upstream of E4.5 control point	Cool – 4 to 6 deg. C. for water; 6 to 9 deg. C for sediment-oil mixture	No booms, curtains, dikes, chevrons, or sediment traps except existing Morrow Lake Dam	--

Question addressed	Stream flow conditions	Sediment conditions	Temperature conditions	River-management practices	Range of dates (if using a recorded flow scenario)
Effective location of sediment containment areas	Annual regime of streamflows for 3 different years: one in lower quartile of annual mean Q, one near median, and one in upper quartile.	Use sediment rating curves to estimate input concentrations at upstream gauges, and estimate sediment inputs from tributaries	Use interpolated estimates from NWS observation network	Include scenarios with only SCA traps, others with SCA traps plus booms/curtains	TBD
Effects of different agitation/recovery methods, e.g., aggressive agitation within Ceresco Dam impoundment	Annual regime of streamflows for 3 different years: one in lower quartile of annual mean Q, one near median, and one in upper quartile.	Use sediment rating curves to estimate input concentrations at upstream , and estimate sediment inputs from tributaries	Use interpolated estimates from NWS observation network	Compare currently used methods with: deeper, more aggressive agitation; and perhaps with sonic/ultrasonic	TBD
Other scenarios, TBD through SOSG discussions	TBD	TBD	TBD	TBD	TBD

[Notes: cfs, cubic feet per second; mg/L, milligrams per liter; R.I., recurrence interval; FD%, flow-duration non-exceedance percentage; ft^2, square feet; --, not applicable; all scenarios shall be simulated using full model domain and constructed as extensions of the fully calibrated Fall 2011 baseline; TBD, to be determined]

Data from quarterly monitoring activities through the Spring 2012 ice-out and snowmelt runoff periods shall be compiled and used to update the model for further simulations during the April-June 2012 quarter. Those simulations would focus on two goals: (1) understanding the river observations collected during December 2011through March 2012; and (2) predicting likely outcomes of a second series of management experiments (or modifications to pre-existing experiments) that would be planned for implementation during the mid-Summer to early-Fall 2012 period. Unforeseen developments in hydrologic, sediment, or oil conditions could motivate more frequent cycles of incremental scenario formulation, simulation, interpretation, decision making, and management implementation. Nevertheless, a long-term timeline could be constructed on a backbone of semi-annual circuits of the adaptive-management cycle.

4.4 Temperature Effects on Submerged Oil

This Work Plan is to evaluate the effect of temperature on the relative occurrence of oil/sheen on the water surface upon agitation of sediment at various temperature ranges. The objectives of this study of temperature effects on submerged oil is to enhance the understanding of the effects that water and sediment temperatures have on submerged oil liberation and the subsequent effectiveness of recovery methods.

4.4.1 Overview

During recovery operations the fraction of oil that is recoverable by toolbox techniques released from the sediment underlying the water column by agitation. The agitation causes submerged oil to rise to the water surface where the oil is collected and appropriately disposed. The oil properties (e.g., density and viscosity) that facilitate its movement to the water surface are sensitive to temperature (Kong, 2004; Fingas et al., 2006). As water and sediment temperatures decrease, oil density and viscosity are both expected to increase. The study described in this Work Plan attempts to evaluate the temperature effects on the relative quantity of oil/sheen that rises to the water surface upon agitation of sediment at various temperature ranges.

4.4.2 Objective

The objective of the bench-scale study is to identify the lower threshold temperature at which the fraction of oil that is recoverable by toolbox techniques does not readily reach the water surface and sheen upon being mechanically agitated. The oil contaminated sediment behavior shall be observed in ranges of temperatures discussed later in the Work Plan. The threshold temperature shall be the temperature at which oil is absent at the surface or has only a light presence. The evaluation of the temperature effect shall be semi-quantitative because the threshold shall be determined relative to observations at other temperatures.

4.4.3 Study Procedures

Sediment and water samples shall be collected from the Kalamazoo River and transported to the field laboratory where the tests shall be conducted. The study design and data collection parameters are presented in Attachment D. The laboratory shall be housed in a field trailer or a house garage that is ventilated and contains adequate space for the study. Appropriate health and safety procedures shall be followed in accordance with the Site Health and Safety Plan (―HASP") (Enbridge, 2010a) and any other approved applicable guidance. The U.S. EPA and/or MDEQ observers shall provide oversight for the entire testing process.

4.4.3.1 Sediment Collection

River sediment shall be obtained from a depositional area that is likely to contain heavy oil based upon screening using poling and selected in collaboration with the SOSG. A petite Ponar® sampler or similar device shall be used to collect and place the grab sample of sediment (approximately 6 liters each) into each of five 7½-liter plastic containers. The petite Ponar® or alternative sampling method shall be deployed to sample shallow sediments where oil is believed to be present, not greater than 5-inches in depth. Sediment samples in all five containers shall be observed and photographed under natural and UV light and the appearance of the sediment, texture, color, debris, and other notable features, shall be described. The general presence of sheen/oil on the sediment shall be noted under visible light and confirmed using a portable UV light viewed under a light blocking hood. The presence, size, and percent abundance of globules under both visible and UV light shall be recorded.

Two of the five sample containers shall be covered with river water in the field by tilting the container at an angle and very gently pouring river water into it before slowly returning it upright being careful not to disturb the sediment. These samples shall be agitated in the field to confirm that the sediment releases sheen upon agitation to ensure that the location selected for sampling contains sheen-generating oil. If the samples do not produce sheen, consideration of river water and sediment temperatures shall guide operational decision to warm these two samples and repeat the agitation and evaluation as described: if the warmed samples still produce no sheen, an alternative area of submerged oil shall be sampled. The three sample containers that are not agitated in the field shall be covered with a lid for transport to the field laboratory for the study and the two agitated samples shall be disposed following proper waste disposal procedures. Samples of sediment and river water retained for the bench study shall be chilled to between 32° F and 40° F, but not frozen, and retained cold until the sample is used in the bench study. Sample disturbance and movement shall be minimized, and every sample shall be handled in the same way. In addition to the sediment grab samples, approximately 23 liters of river water shall be collected for the study. Sediment in the three containers brought in from the field shall be sampled and analyzed for particle size distribution.

4.4.3.1.1 Sampling Location

The sediment samples for testing shall be collected at a depositional location where sheening and globules released by poling have indicated the presence of ―heavy” sheening from submerged oil, which has been presumed to indicate substantial concentration of oil in sediment. The initial location and representative depositional setting shall be selected in consultation with the SOSG to be representative of an agreed upon depositional setting (e.g., backchannel, oxbow, cutoff, dam, island, or delta) and sediment type (very fine sand, silt or organic muck). The study design may be applied to different depositional environments and sediment types after completion of the initial study depending on review of study design effectiveness by the SOSG. One sampling crew comprised of three persons with the U.S. EPA and/or MDEQ oversight shall collect the samples during the course of one day.

4.4.3.1.2 Sampling Methods

Sediment samples shall be collected following the applicable sediment sampling SOP presented in the approved SAP as amended (Enbridge, 2011b) particularly Section 6.3.2 (entitled ―Ponar® or Ekman dredge Sampling”) found in SOP EN-202.

4.4.3.2 Controlled Temperature

The sample design includes testing three replicate samples at five different target temperatures for a total of 15 trial tests as summarized in Attachment D. Each replicate sample shall consist of equal volume aliquots from each of the three remaining undisturbed grab sample containers, for a total replicate sample volume of 400 milliliters (―ml”). In order to maintain as undisturbed sample as possible, the splits for the lab analysis shall be taken directly from the grab sample. For example, replicate sample #1 at temperature #1 shall consist of approximately 133 ml of sediment taken from each of the three grab samples for a total sediment sample volume of approximately 400 ml. The aliquots shall be placed into a 2-liter beaker (7.5-inches tall and 6.25-inches in diameter). A split sample shall then be collected from each of the three grab samples using the same sampling methods, and prepared for laboratory analysis of a single composite sample. The split sample shall be homogenized, and the sample shall be analyzed for TPH measured as DRO and ORO, and TOC. The sediment remaining in the replicate sample beakers shall then be covered by river water, filling the beaker to 1½ liters. Three beakers shall be placed into a temperature controlled, bench top circulating water bath that is set at the desired target temperature. Target water bath temperatures are 35° F, 45° F, 55° F, 65° F and 75° F. Samples shall initially be in storage at temperatures between 32° F and 40° F and shall be placed into the water bath and allowed to equilibrate for one hour, then water and sediment sample temperatures shall be monitored using a digital thermometer (e.g., Omega HH11B) and recorded at 15 minute intervals until both water and sediment temperatures are stable and within 4° F of the target temperature. The water and sediment may equilibrate at different temperatures and at different times given the different heat capacities of the two matrices. Equilibration and monitoring times may be adjusted in response to the time required to achieve stabilization, if warranted. Other changes to sample design or procedures that result from lessons learned during the study shall be documented.

Once the sediment and water temperatures are stabilized within the target temperature range, the initial appearance and percent coverage of sheen and the number of globules on the water surface shall be recorded. The percent of sheen coverage shall be estimated by counting the number of squares on a clear rigid acetate grid (e.g., 5 by 5 equals 1 inch) that is placed on top of the beaker, which has a surface area of approximately 0.213 square feet.

4.4.3.3 Sediment Agitation

Samples shall be agitated in the temperature controlled environment and the parameters presented in Attachment D shall be recorded. Samples will be examined under visible and UV light and documented via photographs as well as with field notes to confirm the presence of oil. Prior to each agitation, sheen on the surface of the water in the sample container shall be removed with sheen net, wipe or other absorbent device. As the sheen is removed, care shall be taken to reduce motion so that the sediment in the container is not agitated, and also so that the sheen is not further smeared onto the edges of the sample container.

The general appearance of sheen (gray, silver, metallic/transitional) and percent coverage and the presence, size, and abundance of globules on the water surface shall be noted prior to the initial agitation. Using a Nalgene® rod (selected to be representative of poling), the sediment shall be stirred, initially with one complete circle, and a description of the appearance of sheen and globules on the water surface shall be recorded.

Photographs under visible and UV light shall be taken; the angle of incident light shall be adjusted to best reveal the sheen in the image. Following the initial stir and observations, the sheen shall be removed from the surface of the water. The sediment shall then be stirred three more times; this second agitation shall occur within 15 minutes of the initial agitation (otherwise, temperatures of water and sediment would need to be re-measured prior to the second agitation). The three stirs shall start in the middle of the sample and work outwards with each turn. The appearance and percent coverage of sheen and globules shall be noted after completing agitation and photographed under visible and UV light.

For consistency, the same person shall agitate each replicate sample at nearly the same temperatures within the targeted temperature range, while making every effort to follow the exact same procedures. Similarly, a single observer shall be estimating the percentage surface area coverage for all samples. Photographs of the sheen on the surface of the water shall be taken for each agitation as stated above. For at least 25% of the visual observations of the amount of sheen present, the photographs shall be quantitatively analyzed to confirm the accuracy of visual estimation of percentage cover by sheen.

Water and sediment temperatures shall be re-measured immediately following the recording of all observations and photographs to verify that conditions remained within the target temperature range.

4.4.3.4 Final Warm Agitation

All replicate sample sets shall be warmed by heating the bath to 75^{o} F and the sediment shall be agitated again with three stirs of the sediment as described above. The sheen shall be removed from the surface of the water prior to heating so that any oil liberated during heating is documented. Agitation at a warm temperature following the bench test shall be used to confirm that a lack of or a reduced amount of sheen was due to the effects of the lower temperature and not a lack of oil in a sediment aliquot. After the final warm agitation, sheen will be removed. The water will then be decanted and the presence or absence of sheen/oil in the remaining sediment will be documented via photographs using visual and UV observations.

4.4.4 Data Evaluation and Reporting

The data on presence or absence of oil/sheen at tested temperatures shall be analyzed to evaluate the effects that temperature has on submerged oil liberation. Consistency between replicate samples within a temperature range shall be assessed to evaluate reliability and uncertainty of the results. This information can be used in the design of any subsequent studies to clarify the results or investigate oil bearing sediment from other depositional environments.

A completion report shall present the experimental results and explain the effects of temperature on the liberation of oil/sheen from sediments. The report shall address the application of the results of this or possible additional studies (as evaluated by the SOSG) to different depositional environments, and shall discuss the study design effectiveness. Results and conclusions may be used to help guide future submerged oil recovery efforts. As appropriate, the report shall provide applicable conclusions based on geomorphic settings and depositional environments that can be classified as similar.

4.4.5 Insitu Temperature Study

Submerged oil assessment and recovery work performed during October 2011 was completed in accordance with the *Submerged Oil Recovery Standard Operating Procedure* (Enbridge, 2011). In support of the submerged oil recovery operations a river study was conducted between October 14 and 29, 2011 to assess the relationship between liberation of submerged oil from sediment as a function of water temperature. Water temperature potentially affects the liberation of submerged oil since physical characteristics including viscosity, solubility, and volatility are typically influenced by temperature. Recovery work by some methods may be less effective as water temperature decreases during the late fall and winter seasons. Poling methods at selected locations, not subjected to recovery activities on the Kalamazoo River, were used to agitate sediment and document oil release as a function of water temperature. A Report of Findings will be developed as part of the above temperature effects bench-study. This Report will outline the methods and procedures followed and the results of the river study.

4.4.6 Additional Temperature Effectiveness Studies

The need for additional field or laboratory temperature effectiveness studies shall be evaluated by the SOSG. The SOSG shall evaluate additional information from this study as well as other studies and multiple lines of evidence as necessary to understand the effectiveness of overall oil recovery. In addition, water and sediment temperature data shall be collected from established USGS and site-specific staff gauges on an ongoing basis for use in validating current and future temperature effects studies and in other applications, as appropriate.

4.5 Submerged Oil Quantification

A scientifically-based model shall be used to calculate the volume of submerged oil for the entire affected water way. This includes Talmadge Creek and the Kalamazoo River (from the confluence with Talmadge Creek through a location immediately downstream of the Morrow Lake Dam), corresponding to MP 0.0 through MP 40.00.

The model shall be populated with chemical, physical, and geotechnical (i.e. sediment thickness) data obtained from sediment cores collected after submerged oil recovery activities as well as post-recovery poling activities that were completed in 2011. This process shall be similar to that used to perform the submerged oil quantification calculated based on pre-Summer 2011 oil recovery activities. The Spring 2011 Quantification Model and Report will be finalized in consultation with the SOSG. Only data collected under the U.S. EPA and/or MDEQ approved work plans shall be used in the proposed evaluation.

4.5.1 Objectives

The objective is to quantify the volume of submerged oil from the Enbridge Line 6B Incident that is present in the sediments in Talmadge Creek and the Kalamazoo River from the confluence with Talmadge Creek down to Morrow Lake at the time of each quantification event. This information will be used by the SOSG in consideration of future activities.

Quantification of submerged oil shall be performed at the following times, and at other time directed by the U.S. EPA:

- Fall 2011– after Summer/Fall 2011 oil recovery activities are complete;
- Spring 2012 – prior to performing 2012 oil recovery activities; and
- Fall 2012 – after Summer/Fall 2012 oil recovery activities are complete.

4.5.2 Quantification Model

This section describes the numeric model that shall be used to estimate the amount of submerged oil remaining in the Kalamazoo River (including the Morrow Lake Delta and Morrow Lake).

A model was previously developed to quantify the amount of submerged oil in sediment identified during the Spring 2011 reassessment of Talmadge Creek and the Kalamazoo River (including the Morrow Lake Delta and Morrow Lake). This same conceptual model shall be the basis for Fall 2011 (post-2011 oil recovery activities), Spring 2012 (pre-2012 oil recovery activities), and Fall 2012 (post-2012 oil recovery activities) models for submerged oil quantification.

These subsequent models shall use:

- Variable 1 – Measured TPH concentration in sediment. An alternative to using TPH results may be considered by the U.S. EPA in consultation with the SSC Group.
- Variable 2 – Sediment bulk density.
- Variable 3 – Lateral extent of oil-impacted sediment.
- Variable 4 – Vertical extent of oil-impacted sediment.
- Variable 5 – Density of released oil, adjusted for weathering.

The models shall utilize a spreadsheet to calculate the volume of impacted sediment. Once calculated, the mass of oil impacted sediment shall be determined from the impacted volume and sediment bulk density. These volume calculations shall be performed separately for different sub-regions of the total oil-impacted river system, where individual sub-regions will be reviewed with the SOSG and may correspond to: 1) subareas of the river designated by similar submerged oil category: heavy, moderate, or light, as determined by poling (i.e., poling-delineated areas): and 2) separate vertical layers or strata within those subareas (e.g., defined by similar sediment type). Subsequently, the mass of oil present in each stratum shall be calculated based on a representative concentration value (either a simple summary statistic or the estimated value from a linear statistical model) of laboratory- reported TPH concentrations and total impacted sediment mass. Finally, the volume of submerged oil shall be calculated from an approximation of the density of the weathered crude. The algorithm used in the model shall be as follows:

Gallons of Oil (gal) in stratum $\boldsymbol{j}$ =

$$\{[D_{\boldsymbol{j}}\text{ (inches)} * A_{\boldsymbol{j}}\text{ (acres)} * P_{\boldsymbol{j}} * 4{,}046.86\text{ (m}^2\text{/acre)} * 0.0254\text{ (m/inch)}$$

$$*P_{Sed\,\boldsymbol{j}}\text{ (g/cm}^3\text{)} * 10^6\text{(cm}^3\text{/m}^3\text{)} * TPH_{\boldsymbol{j}}\text{ (mg/kg)} * 10^{-6}\text{(kg/mg)]}$$

$$/P_{Oil}\text{(g/cm}^3\text{)}\} * 10^{-3}\text{(L/cm}^3\text{)} * (0.2642\text{ gal/L)}$$

Where:

A_j = Total Area of Interest (acres)

P_j = % of Area of Interest with TPH Concentration (decimal equivalent)

D_j = Thickness of oil impacted sediment layer (inches)

$P_{Sed\,j}$ = Dry density – sediment (g/cm^3)

P_{Oil}= Density – oil (g/cm^3)

TPH_j = Representative concentration (e.g., linear model estimate, arithmetic mean, median, and/or geometric mean) of submerged oil concentration in stratum j (mg/kg) –. Coverage provided for light, moderate, and heavy poling designations with the mean TPH value used to calculate the concentration of each tenth foot interval of the array for sample cores.

Data sources include:

P_j (% of area of interest with TPH concentration) from poling-delineated areas for “heavy” and “moderate” categories, and either mixing-model or frequency based analysis for “light” and “none” categories.

D_j (Depth of oil layer) = from thickness of oil-containing sediments as indicated by analytical chemistry data and/or statistical analysis, and/or supplemental data collected from field sampling.

$P_{Sed\,j}$ (Dry density – sediment) = from stratum mean of estimated bulk density measured in sediment containing submerged oil.

$P_{Oil\,j}$ (Density – oil) = from weathering adjustment applied to estimated density of released crude oil, which was assumed to be 0.9285 (g/cm^3) http://www.crudemonitor.ca/ – 5-year average as defined below.

An example of the model is presented below:

Morrow Lake Delta

Total Area of Interest (acres) =	37	1 acre =	4,046.86 m^2
% of Area of Interest with TPH Concentration =	100.0%	1 " =	0.0254 m
Cold Lake Crude Density =	0.9285 ± 0.0005 g/cm3		
Thickness of oil layer (inches) =	6 "	1 L =	0.264172052 gallons
Mean TPH Concentration ± S.D. (mg/kg) =	101 ± 111		
Density of sediment (g/cm^3)= (From bulk density of 1.125 and 48.5% moisture)	1		
n =	44		
Volume of impacted sediment with TPH concentration =	22,819.41 m^3		
Mass of sediment impacted based on impacted volume and bulk density =	22,819.41 kg		
Mass of oil based on concentration =	2,297.0 kg		
Volume of oil based on Cold Lake Crude density =	2473.86 L		
Gallons of oil =	**654 gallons**		

4.5.2.1 Model Architecture

The model shall have an open architecture, whereby it is adaptable and flexible to approximate the amount of oil present in the sediment within specific geomorphic strata, river reaches/lake areas, or broader reaches/lake areas with minimal modifications. It shall be automated and based on the six specific parameters/variables listed above, or more as directed by the U.S. EPA. Output shall be standardized and list key parameters/assumptions used in the model along with summary statistics and evaluations of uncertainty.

4.5.3 Input Data

4.5.3.1 Variable 1 – Measured TPH Concentration in Bed Sediment

The concentration of submerged oil in the bed sediments as of Fall 2011shall be estimated using an estimated 100 sediment cores (or other quantity as directed by the U.S. EPA) collected from apparently oil-containing areas of streambed, plus at least 10 additional cores from areas that demonstrated light qualitative indications of oil. Subsequent sediment core collection shall follow the adaptive management principle to assess the submerged oil in the dynamic riverine system. The purpose of the sediment cores shall be to obtain sediment samples which shall be analyzed to evaluate remaining submerged oil in the Kalamazoo River.

Sediment samples from the sediment cores shall be analyzed for TPH that includes DRO and ORO, and other parameters as directed by the U.S. EPA. The total TPH value provides a potential measure of submerged oil present in the sediments. In the absence of specific TPH data for various elevations at a given location, existing TPH data from that location shall be applied to all depth horizons where qualitative evaluation (i.e., UV fluorescence) indicates the presence of oil.

Information regarding location and methodology for sediment core collection is outlined herein related to the hydrodynamic assessment.

Results for TPH and other variables in the model shall be compared between areas delineated by the light, moderate, and heavy poling designations. An analysis of uncertainty shall be performed for all variables in the model, and for the model outputs (volumes of oil) that considers and incorporates all known sources of error and uncertainty. TPH concentrations shall be presented with standard deviations and the statistical confidence interval(s) shall be presented and discussed in accordance with the statistical validation described herein.

4.5.3.1.1 Background TPH

At a total of 36 background sediment sampling locations (collected upstream of the affected portions of the Kalamazoo River, Battle Creek River, and Talmadge Creek), bed-sediment cores have been collected, sampled, and analyzed. Subject to future U.S. EPA approval, the background data may be included in the submerged-oil volume calculator to account for background TPH concentrations and as a comparison to the presumed historical (i.e., pre-release from Enbridge Line 6B Incident) TPH present in the portion of the Kalamazoo River affected by the Enbridge Line 6B Incident.

The method for incorporating background TPH is currently being evaluated and may be applied to the Spring 2011 submerged oil quantification; therefore, the same method for incorporating background TPH shall be applied to data collected and used as described herein.

4.5.3.2 Variable 2 - Sediment Bulk Density

As described in the hydrodynamic assessment, bed sediment cores paired with each primary core were collected in Fall 2011 to determine the sediment bulk density in the Kalamazoo River. Results from these analyses shall be used for quantification of submerged oil as of Fall 2011.

4.5.3.3 Variables 3 and 4 - Lateral and Vertical Extent of Oil- Impacted Sediment

Poling, analytical data, and core logging data shall be analyzed to infer the lateral and vertical boundaries of sediment impacted by submerged oil. The culmination of these factors shall result in a determination of the volume of sediment containing submerged oil, subject to approval by the U.S. EPA.

The determination of the lateral and vertical extent of submerged oil shall include the area of sediment which poled ―light”, ―medium”, and ―heavy”. The area for sediment which poled ―medium” and ―heavy” will be based directly on the field observations during poling assessments. A method will be developed to identify the sediment areas which poled ―light” and reviewed with the SOSG. The area which poled ―light” will incorporate fluvial geomorphic environment types. All determinations for lateral and vertical extent of submerged oil shall extend to locations of ―none”, and shall not arbitrarily assign an area to the ―light” indications category, as was previously performed. As a minimum, the model shall be applied separately to the following three categories: ―light”, ―moderate”, and ―heavy”. The lateral extent of ―light” poling shall be mapped similar to the ―moderate” and ―heavy” categories. Further, categorization and oil-volume modeling by fluvial geomorphic environment types shall also be performed.

This information shall be used in the model to calculate the submerged oil volume from the sediment sample locations.

4.5.3.4 Variable 5 - Density of Released Oil

The density of weathered oil (―P_{Oil}”) is developed as an adjustment to the assumed density of the crude oil spilled. Based upon a review of Enbridge transportation records and analysis of samples collected by Enbridge after the pipeline restarted, the release appears to have occurred at or about the time that the latter end of a batch of Western Canadian Select (―WCS”) was passing through the pipeline near Marshall, Michigan and a batch of Cold Lake (―CL”) crude had begun.

The composition of the oil released was approximately 77.5% CL and 22.5% WCS. Using this composition (77.5% CL and 22.5% WCS), and the 5-yr average density for each (0.9283 g/cm^3 for CL and 0.9290 g/cm^3 for WCS from *http://www.crudemonitor.ca/* on August 10, 2011), the estimated combined density for a 77.5% to 22.5% mixture would be 0.9285 g/cm^3, which is equivalent to the CL 5-year average. As the nature and cause of the release is still under investigation by National Transportation Safety Board, this determination is based on a number of assumptions regarding the nature and timing of the release. The estimated density of oil shall be adjusted for the probable loss of volatile constituents/fractions and any other appropriate weathering effects, and the resulting adjusted density shall be used for oil-volume calculations.

4.5.4 Statistical Evaluation of TPH Data

Sediment TPH data shall be evaluated using empirical and statistical methods to assess data distributions and relationships within TPH concentration data to estimate the submerged oil present within the river system. Only data collected under the U.S. EPA and/or MDEQ approved work plans shall be used for this task.

The statistical evaluation shall be used to support the calculation of submerged oil in Talmadge Creek and Kalamazoo River sediment, and shall consist of the following elements:

- Evaluation of the dataset to determine if lithology, depth/thickness, and/or other factors result in specific groupings or populations of data enabling segregation and/or separate statistical evaluation/testing;
- Determining a probability mass function to define the discrete probability distributions of the population(s) identified in the evaluation;
- Calculating interquartile ranges, standard deviation and variance of the populations identified in the evaluation;
- Evaluating the various geomorphic surface types; and
- Developing a statistically-based method for approximating the amount of oil present and confidence interval for this estimate within the Talmadge Creek and Kalamazoo River.

The evaluation shall use collected data in all oil-containing sediment areas (light, moderate, and/or heavy). Depending on the population(s) distributions (i.e., normal vs. not normal or skewed determined by normality tests such as Shapiro-Wilk, Anderson-Darling, or as most appropriate to the dataset), parametric or non- parametric (e.g. Kruskall Wallace, Mann-Whitney) statistical significance tests shall be conducted, as warranted and as approved by the U.S. EPA. If required based on the outcome of the empirical and/or statistical evaluation, approximation of the amount of oil present and confidence interval for this estimate may vary per river segment, with the total amount of submerged oil being the sum of such individual segments. Descriptive statistics (e.g.

mean, median, range, standard deviation, confidence interval) along with quartile plots and other graphical presentations of the data shall be provided.

4.5.5 Reports

A report shall be submitted to the U.S. EPA following the completion of each quantification event. Each report will present the data, calculations, and results.

5.0 OIL RECOVERY

5.1 Objectives

Perform additional oil recovery actions, as necessary, to meet the U.S. EPA Order.

5.2 Submerged Oil Recovery

Submerged oil recovery actions shall be determined by the U.S.EPA FOSC who will consider the results of the studies outlined in this Work Plan. Potential environmental consequences of implementing specific oil recovery actions shall be evaluated by the U.S. EPA. Evaluations may include considerations of the impacts to the environment of specific recovery actions, such as:

- River bank erosion from boat usage;
- Loss of habitat for aquatic life from large woody debris removal;
- Potential for increased erosion during flood conditions;
- Migration of sediment at an abnormally high rate due to agitation techniques;
- Damage to the benthic community from agitation of the river sediments;
- Injury and death of wildlife due to equipment and boats on the river; and
- Loss of wooded wetland habitat due to excavations.

Submerged oil recovery options that shall be considered by Enbridge include, but are not limited to, the following:

- Dredging of oil-containing sediments;
- Agitation of sediments coupled with oil/sheen collection;
- Installation and maintenance of sediment collection structures/devices; and /or
- No further action.

The need for further active oil recovery shall include an evaluation of ecological considerations, as well as an evaluation of the potential benefits and consequences of active oil recovery, or the lack thereof. This evaluation and decision of adverse ecological risk shall be made solely by the U.S. EPA FOSC following consultation with the SSC Group. The OSG, SOSG, and Containment Science Groups (―CSG") will provide information and recommendations to the SSC Group for their consideration in evaluating ecological risks and advising the FOSC.

Submerged oil recovery shall be addressed using a top down approach working upstream to downstream within each of the three defined sections of the river. The first section shall consist of a portion of the river starting at the confluence of the Talmadge Creek and the Kalamazoo River and ending at the Ceresco Dam. The second section begins at the Ceresco Dam and ends at the Battle Creek impoundment. The final section runs from the Battle Creek impoundment to the Morrow Lake Dam.

5.2.1 Winter 2011 Submerged Oil Recovery Actions

Over the winter months, passive recovery locations for submerged oil activities shall be evaluated by the SOSG. Passive recovery techniques shall be used to collect submerged oil mobilized by natural river flow conditions. The identification of these locations shall be informed by the hydrodynamic Model, LSR 2011 results, historic poling data, and fluvial geomorphic observations. Structures designed for collection of submerged oil shall utilize the dynamic nature of the river while minimizing the ecological impact of recovery activities on the river system. Additional discussion of the evaluation, installation, and maintenance of sediment collection devices and locations is provided in Section 7.

Active recovery of submerged oil may occur via the use of approved techniques at select locations as determined by the SOSG, OSCAR, and other advisory groups identified by the U.S EPA.

5.2.2 Spring/Summer 2012 Submerged Oil Recovery Actions

Active and/or passive submerged oil recovery actions shall occur throughout Spring/Summer 2012 based on the results of Spring 2012 reassessment activities, SSC Group and SOSG recommendations to the FOSC, and other factors. Submerged oil recovery activities using agitation techniques shall be conducted only while water and sediment temperatures are conducive to submerged oil recovery as determined through the results of the temperature effects studies described in Section 4 and shall be based on techniques presented in the approved Summer 2011 Strategic Work Plan and Dredging Supplement, or approved alternate means and methods. Although work may be conducted pursuant to the U.S. EPA Order, it shall not obviate the need to comply with all federal, state and local permitting, monitoring, and other requirements.

Addenda to this Work Plan outlining specific active and passive submerged oil recovery locations, activities, equipment, and procedures shall be submitted prior to implementation. Work Plan addenda shall take into account all potential environmental impacts as evaluated by the SOSG and SSC Group when outlining proposed activities.

5.3 Shoreline and Overbank Oil Recovery

Shoreline and Overbank oil recovery actions shall be conducted based on the OSCAR Branch evaluations of reassessment results, location-specific recovery work plans submitted to the U.S. EPA, and based on data obtained from expedited remedial investigation activities pursuant to the MDEQ approved work plans.

If the FOSC determines that additional recovery actions at impacted shoreline and overbank locations shall be addressed under the U.S. EPA Order, the appropriate permits shall be obtained prior to the commencement of oil recovery actions. Permit compliance requirements such as water quality monitoring shall be conducted pursuant to applicable SOPs.

One or more of the approved shoreline and overbank oil recovery techniques shall be implemented to recover oil, sheen, or impacted soils. The selection of the technique or techniques for each impacted area shall consider: accessibility; ecological sensitivity and benefit/consequence; type of oil impact present; depth of oil in soil; and other factors.

Approved oil recovery techniques for impacted floodplain areas are presented in the *Overbank Oil Recovery SOP* (included as Attachment E to this Work Plan). Other overbank oil recovery procedures and requirements shall follow those presented in Sections 2.0 and 3.0 of the approved Summer 2011 Strategic Work Plan, or via alternative procedures and methods approved by the U.S. EPA.

6.0 FALL 2011, WINTER AND SPRING 2012 CONTAINMENT PLAN

The objectives of the containment plan for Fall 2011 and Winter/Spring 2012 are to implement a strategy in the Kalamazoo River/Morrow Lake Delta/Morrow Lake to prevent further migration of oil sheen and/or submerged oil into Morrow Lake and to prevent migration of oil sheen and/or submerged oil from Talmadge Creek into the Kalamazoo River. At the time of document submittal, the Fall 2011 containment removal activities outlined within this section have been completed.

Considerations included in accomplishing these objectives are:

- Personnel and public safety;
- Limit impact to downstream receptors such as culverts, bridge structures, and dams in the river;
- Removal of surface containment features prior to winter freeze up in an efficient manner, particularly in the Morrow Lake Delta and Morrow Lake;
- Development, installation, and maintenance of a submerged oil containment plan to enhance sedimentation in the Morrow Lake Delta, and to control further migration of submerged oil into Morrow Lake and potentially over the Morrow Lake Dam. Submerged oil containment measures may be implemented at other areas in the Kalamazoo River based on results of hydrodynamic modeling;
- Manage any winter containment sites that are left in place; and
- Installation of Spring 2012 containment features according to an addendum to this Work Plan outlining the specific Spring 2012 Containment Plan.

Containment will be removed during Fall 2011 on a priority basis and in a controlled systematic manner under the direction and approval of the U.S. EPA. Containment deployment in Spring 2012 will be based on weather and site conditions, predictive modeling of Spring submerged oil work sites, and at the direction and approval of U.S. EPA.

This containment plan is based on the current strategies that are to be implemented in the fall 2011 and Winter/Spring 2012 work seasons. The identified containment removal and deployment strategies may be modified if any changes in this Work Plan take place based on weather conditions, Spring 2012 reassessment findings, river characteristics, results of hydrodynamic assessment components as detailed in Section 4.2, presence of surface or subsurface residual oil, or any other factor that could cause a change in this Work Plan.

6.1 Fall/Winter Containment Removal Procedure

Containment removal will be executed in a controlled manner at the recommendation of the Containment Branch Science Group and the direction and approval of the U.S. EPA. Visual monitoring of sediment and sheen levels downstream of the containment during containment removal will be conducted by field inspectors and from over-flights. If visual levels of sediment or sheen are noted during the observations, the conditions will be noted and sheen collection will be performed using sheen sweep boat(s). The addition of temporary downstream containment may be required.

Containment approved for removal shall be decommissioned as follows:

- Non-impacted debris accumulated in the retention area of the boom shall be collected and properly disposed. Residual sheen in the contained area shall be removed with sorbent sweep. Boom determined to be collecting new sheen shall not be removed without prior approval from the U.S. EPA.
- The lines securing the downstream end of the containment shall be released starting with the shoreline protection. The retention area line shall then be slowly released allowing the containment to settle onto the upstream anchor. If excessive levels of sediment or sheen are noted the shoreline retention line can be re-secured to allow them to settle out.
- Any sediment or X-Tex curtain attached to the boom shall then be cut free and loaded into boats and taken for disposal.
- Boom shall be towed to the nearest boat launch where it shall be loaded directly from the water into roll-off bins. Boom shall be taken for decontamination and repairs. Boom shall then be sorted and properly stored for winter to prevent dry rot and UV damage. Any boom that is too damaged shall have the metal fittings removed and be properly disposed.

6.2 Removal Priority and Scheduling

Priority sequence for removal is as follows:

- Removal of containment associated with submerged oil sites;
- Removal of control point containment; and
- Removal of protective containment points associated with OSCAR sites.

This sequence is based on several factors listed below:

- Areas with the potential to have ongoing sheen issues should be removed last to prevent additional impact to downstream receptors.
- Control points should be left in place until submerged oil operations are completed.
- Enbridge shall continue consultation with STS Utilities regarding placement and removal schedules for all containment between Morrow Lake and Morrow Lake Delta (35th Street to Morrow Lake Dam).
- OSCAR locations should be removed as late as reasonably possible. OSCAR sites that are in sheltered locations, where ice damage is not anticipated, may be left in place and monitored through the winter.
- Containment shall be removed from OSCAR sites that have received determination as being consistent with the U.S. EPA Order.

- The presence of frazil ice or dislodged sheet ice flowing within the main river channel.

The schedule for the containment removal plan shall be based on the above priority sequence. The implementation of the containment removal plan is largely dependent on fluctuating weather and river conditions and may be delayed by a down turn in either of these factors. If, due to fluctuations in the weather, the potential for ice or debris dams increases once containment removal has begun, removal activities shall be limited. Additionally, any remaining boom shall be monitored for a potential loss of integrity so that corrective actions can be taken.

6.2.1 Submerged Oil Containment Removal Schedule

Submerged oil containment shall be removed as sites after the U.S. EPA has directed Enbridge to discontinue submerged oil recovery activities due to low water and sediment temperatures and has approved the removal. Removal of submerged oil containment sites shall generally be conducted following the top down approach.

6.2.2 Control Point and Protective Containment Removal Schedule

Control point and protective containment removal shall begin after the completion of submerged oil activities, with the approval of the U.S. EPA. High priority sites in the Kalamazoo River, Morrow Lake Delta, and Morrow Lake that shall require further evaluation for removal are:

- MP 36.6N;
- MP 36.8 N;
- Morrow Lake Delta Channel 6;
- MP 37.25; and
- MP 37.75.

Enbridge shall remove all surface containment between 35th Street Bridge and Morrow Lake Dam by November 18, 2011 as per the request of STS Utilities or as otherwise negotiated at the direction of the U.S. EPA. The confluence containment point (MP 2.25) shall remain in place throughout the winter. The projected order of removal shall be:

1. MP 6.0;
2. MP 10.8;
3. D 3 (MP 19.25);
4. C 6 (MP 15.25);
5. E 4.5 (MP 38.25);
6. E 4.75 (MP 38.25);
7. E 6 (MP 39.75);
8. Ceresco (MP 5.75);
9. MP 15.75;
10. E 4 (MP 37.75); and
11. E 5 (MP 38.25).

This sequence is subject to change dependent on site conditions, weather, operational activities and approval or direction from the U.S. EPA.

6.2.3 OSCAR Containment Removal Schedule

OSCAR containment shall be removed at the direction of the U.S. EPA. Removal of the OSCAR containment sites shall generally be from upstream to downstream. OSCAR sites that do not receive a determination as being consistent with the U.S. EPA Order will be evaluated by the U.S. EPA for potential to leave containment in place during the winter months.

6.2.3.1 Fall 2011

Site monitoring shall be conducted during Fall 2011 utilizing boats, as well as land and air based observations. During monitoring, crews shall observe river characteristics such as freezing, movement of flowing ice, debris movement (including vegetation/debris dislodged during fall vegetation die back and accumulated organic matter), and visual checking for the presence of surface oil/sheen. The information collected during these activities shall be utilized for determining the priority sequence and timing of containment removal.

6.2.3.2 Winter 2011/2012

Site monitoring shall be conducted during the winter, utilizing boats, as well as land and air based observation. During monitoring, sites shall be evaluated for ice buildup, debris accumulation and containment integrity as well as visual checking for the presence of surface oil/sheen. The information gathered during monitoring shall be utilized for determining required boom maintenance, as well as adjustment and installation of additional containment measures.

6.2.3.3 Spring 2012

Site monitoring shall be conducted during the spring months, utilizing boats as well as land and air based observation. During monitoring, crews shall observe river characteristics such as freezing, movement of flowing ice, debris movement (including vegetation/debris dislodged during spring runoff and accumulated organic matter), and visually checking for the presence oil/sheen. The information collected during these activities along with the Spring 2012 Containment Plan shall be utilized for determining the priority sequence and timing of containment deployment.

6.2.4 Submerged Oil Containment to Prevent Migration of Oil Past Morrow Lake Dam

As directed by the U.S. EPA in a letter to Enbridge (dated November 4, 2011), Enbridge shall prepare a plan for preventing oil from migrating past the Morrow Lake Dam during the Winter 2012. This plan, once approved by the U.S. EPA, shall be incorporated as an addendum to this Work Plan. The work plan for Preventing the Migration of Oil Past the Morrow Lake Dam shall describe in detail the necessary actions that Enbridge will take to contain and prevent the migration of oil, sheen, submerged oil, and oil-containing sediments past/downstream of the Morrow Lake Dam. The plan shall describe methods for enhancing submerged oil deposition in the Morrow Lake Delta and shall include options that decrease river velocities and promote and enhance deposition such as installation of bed structures and adjusting the level of the Morrow Lake Dam during flood events to reduce velocities in the Morrow Lake Delta and promote deposition and reduce sediment migration.

6.2.5 Winter Maintenance Procedure

Throughout winter operations all locations requiring boom, if any, shall be monitored. Any site that becomes damaged or dislodged by ice or other causes shall be removed, replaced or repaired depending on the potential for downstream impacts versus the potential for additional damage as approved by the U.S. EPA. All locations shall be monitored on a weekly basis to ensure their integrity.

6.2.6 Spring 2012 Containment Plan

6.2.6.1 Control Point Booming

Control point booming is the use of containment boom, curtain boom, silt fence and/or X-Tex curtain to prevent the downstream migration of surface and/or subsurface oil. Control point booming, when properly deployed, shall aid in facilitating the recovery of migrating surface and subsurface oil. There are several booming strategies that shall be used in control point booming, including the following:

- Shore to Shore Booming: This strategy involves a single span of boom that is deployed to cover the entire width of the river. The upstream end of the boom is secured to an anchor point on the upstream bank. Hand lines or in-stream anchors are used to maneuver the boom at the appropriate angle (dependent on current velocity) down to a recovery area. A small section of boom is then deployed along the downstream shoreline to prevent impact to the river bank (shoreline protection).
- Gate Booming (also referred to as ―Open Chevron"): This strategy involves two segments of boom that are deployed across the width of the river to allow for vessel traffic up and down the river. The upstream ends of both booms are secured in an overlapping position using in-stream anchors. Hand lines or in-stream anchors are used to maneuver the boom at the appropriate angle (dependent on current velocity) down to a recovery area. A small section of boom is then deployed along the downstream shoreline to prevent impact to the river bank (shoreline protection).
- Cascade Booming: The cascade boom system is the deployment of multiple booms across the width of the river to allow for vessel traffic up and down the river or to reduce the strain that current places on individual spans of boom. The upstream boom is secured to the shore at its upstream point. Using hand lines or in stream anchors, the boom is maneuvered at an appropriate angle (dependent on current velocity) to a point in the river where it is secured with an in-stream anchor. Each additional segment is then placed downstream in an overlapping position and secured with in-stream anchors. The last span of boom is secured on its downstream end to the shore. A small section of boom is then deployed along the downstream shoreline to prevent impact to the river bank (shoreline protection).
- Chevron Booming: The chevron boom system is a single span of boom that is deployed to deflect oil/sheen around a sensitive area or to recovery points on both banks. The center of the boom is secured in the middle of the channel using an in-stream anchor. Hand lines or in-stream anchors are used to maneuver both of the downstream booms at appropriate angles (dependent on current velocity) down to recovery areas. Small sections of boom are then deployed along the downstream shoreline to prevent impact to the river bank (shoreline protection).

Control point booming location sites shall be selected based on the following criteria:

- River characteristics (current speed, depth, width and bottom material);
- Site access (ease of oil recovery and maintenance);
- Suitable anchor points;
- Distance to upstream control points;
- Distance to upstream sources of impact (identified impacted depositional areas and impacted overbank areas); and
- Access control to prevent impact to the public.

Currently, control points have been identified as likely locations for installation of surface containment. The number of control points to be deployed shall be dependent on information gathered during spring monitoring activities, the Spring 2012 reassessment, and potential river reopening activities. The likely control point locations for Spring 2012 are:

- MP 2.25 (confluence of Talmadge Creek and Kalamazoo River);
- MP 5.75 (Ceresco Dam);
- MP 15.75, C 6 (Battle Creek Dam); and
- Morrow Lake Delta and Morrow Lake.

Due to the increase in water levels associated with spring runoff, all control points shall be installed at a greater angle. This shall lessen the force applied to them by the increased current velocity and reduce the risk of containment failure.

Subsurface containment may also be installed based on the monitoring and reassessment activities. The locations of these sites shall be based on the observations made by the monitoring team as well as the locations of any identified subsurface concerns.

All control points shall be monitored for ice buildup. If there is significant ice buildup, the boom shall be released to prevent an unsafe condition or uncontrolled containment failure.

6.2.6.2 Sediment Trap Containment

During winter operations, engineered sediment traps (passive sediment collectors) may be installed within the Kalamazoo River as detailed in Section 7. During the Spring and Summer 2012 seasons, dependent on site conditions and the presence of surface or subsurface oil, additional containment shall be installed immediately downstream of each sediment trap if directed by the U.S. EPA. This containment, if necessary, would potentially consist of surface and subsurface containment.

6.2.6.3 Protective Containment

Protective containment is the use of surface and subsurface containment to prevent impact to a sensitive area or to prevent impact to the river from a small impacted area. Containment is deployed between a source of impact and the selected area of the river to shield the area from impact. Protective containment can also be used to isolate impacted areas until recovery methods have been completed and regulatory sign-off has been received. The containment shall usually be deployed:

- At the mouth of an inlet;
- Around the entire area; and
- In a chevron (see control point booming) configuration upstream of the area.

The selection of locations for protective containment shall be based on the following criteria:

- Areas that have the potential to cause impact to downstream receptors; and
- Areas of significant ecological value.

Deployment at these locations will be dependent on information gathered during monitoring activities and may vary pending the results of those activities. Additional areas may be added based on inspection results and the identification of unknown areas of impact.

6.2.6.4 Oil Recovery

Oil recovery involves the removal of oil from the surface of the water. All containment locations shall be monitored for the accumulation of oil and impacted debris. When identified, this material shall be recovered and disposed of according to the accepted waste handling practices. Several recovery methods are listed below but are not limited to:

- Hand Skimming: Hand skimming is the removal of oil by physical labor. Personnel shall utilize hand tools such as dip nets, strainers, and pitchforks to lift the oil and debris out of recovery areas and place it into a container for disposal.
- Rotary Skimming: Rotary skimming is the removal of oil by a mechanical rotary skimmer. There are several types of rotary skimmers including drum, mop skimmers and brush skimmers. All rotary skimmers work by rotating a surface with oil adhering qualities. The oil is then mechanically removed from the surface and collected into a container for disposal.
- Vacuum Truck: Utilizing a vacuum unit to remove oil or impacted sediment out of a containment area.

Due to the low volume of oil expected to accumulate during operations, hand skimming shall be the preferred method of oil recovery.

6.3 Deployment Priority and Scheduling:

Priority sequence for deployment is as follows:

- Deployment of surface containment from downstream to upstream;
- Deployment of protective containment at areas of high ecological value;
- Deployment of protective containment from upstream to downstream; and
- Deployment of submerged oil containment (not including submerged oil work sites) from downstream to upstream.

The schedule for the Spring 2012 containment plan shall be based on the above priority sequence. The deployment of containment in spring conditions is largely dependent on fluctuating weather and river conditions and may be delayed by either of these factors. Due to the potential for the formation of ice and or debris dams, booming activities shall be triggered by the absence of the potential for migration of ice and or debris to downstream areas. If, due to fluctuations in the weather the potential for ice or debris dams increases once deployment has begun, booming activities may be limited. Additionally, any deployed boom shall be monitored for a potential loss of integrity so that corrective actions can be taken.

During all work in the river, special consideration shall be given to the following:

- The safety of personnel working in, around, and on the water.
    - Boat traffic shall be kept to a minimum to reduce the risk to workers;
    - If personnel are working in the water from the shoreline a tag line shall be required for any work completed in water greater than waist depth; and
    - Boats working in the vicinity of containment shall do so under a no wake restriction.
- The safety of the public.
    - All sites that are accessible to the public shall be clearly marked with signage warning of the dangers associated with site.

7.0 PASSIVE SEDIMENT COLLECTION AREAS AND DEVICES

Design, installation, maintenance, and removal of passive sediment collection devices described herein will be conducted by the Containment Branch in consultation with the SOSG.

7.1 Objectives

The objective of the installation and use of passive sediment collection devices (―sediment traps") is to collect submerged oil in a minimally invasive manner. Installation of sediment traps in key areas of the Kalamazoo River will be used to more efficiently and less intrusively recover remaining submerged oil.

Sediment traps shall be designed to efficiently take advantage of, and/or enhance, existing flow and depositional patterns in the river. This may include stand- alone traps, a series of traps, or a combination of flow-directing techniques and trap(s), pursuant to recommendations generated from the process outlined below.

7.2 Background

Various geomorphic settings along the active channel and off-channel areas of the Kalamazoo River have been identified as preferential to the deposition of submerged oil and oil-containing sediment. These settings include riparian wetlands, oxbows, flood chutes, cut-off channels, backwaters, point bars, deltas, and impounded areas. In the active channel, areas that may be scoured during floods can be depositional during low flows. Ice jams can also play a factor in determining flow obstructions during winter and spring melts. The location and function of these depositional areas can change depending on whether the river is in flood stage or sustained low flow and will impact the distribution of submerged oil within the river (Figure 7.1). Oil deposits in off-channel/overbank areas from the July 2010 flood may later become sources of oil to channel margins during subsequent floods or as seeps if hydrologically connected during low flows. Such geomorphic considerations are important to proper sediment trap design and site selection (Figure 7.2).

Figure 7.1. Results from the 2011 LSR poling, showing frequency of occurrence of none, light, moderate, and heavy oil indications.

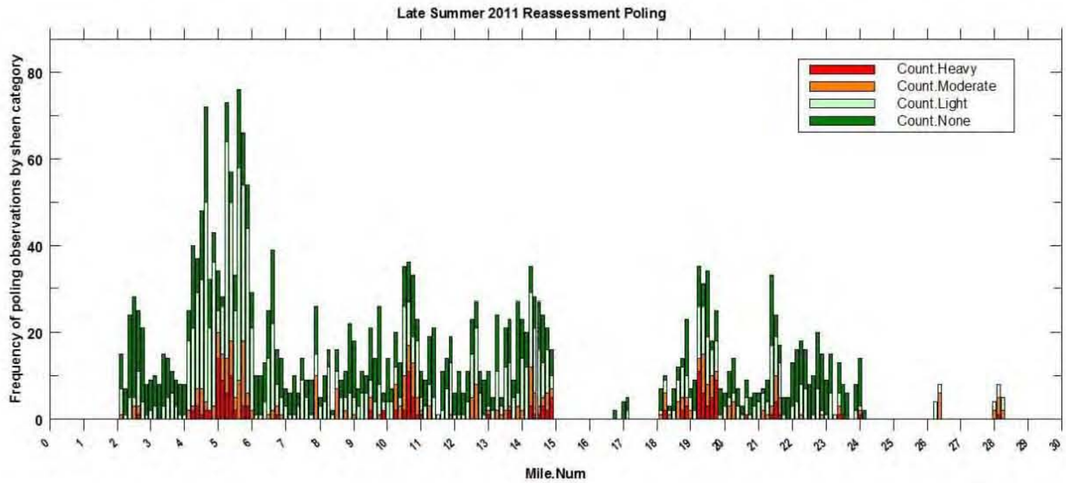
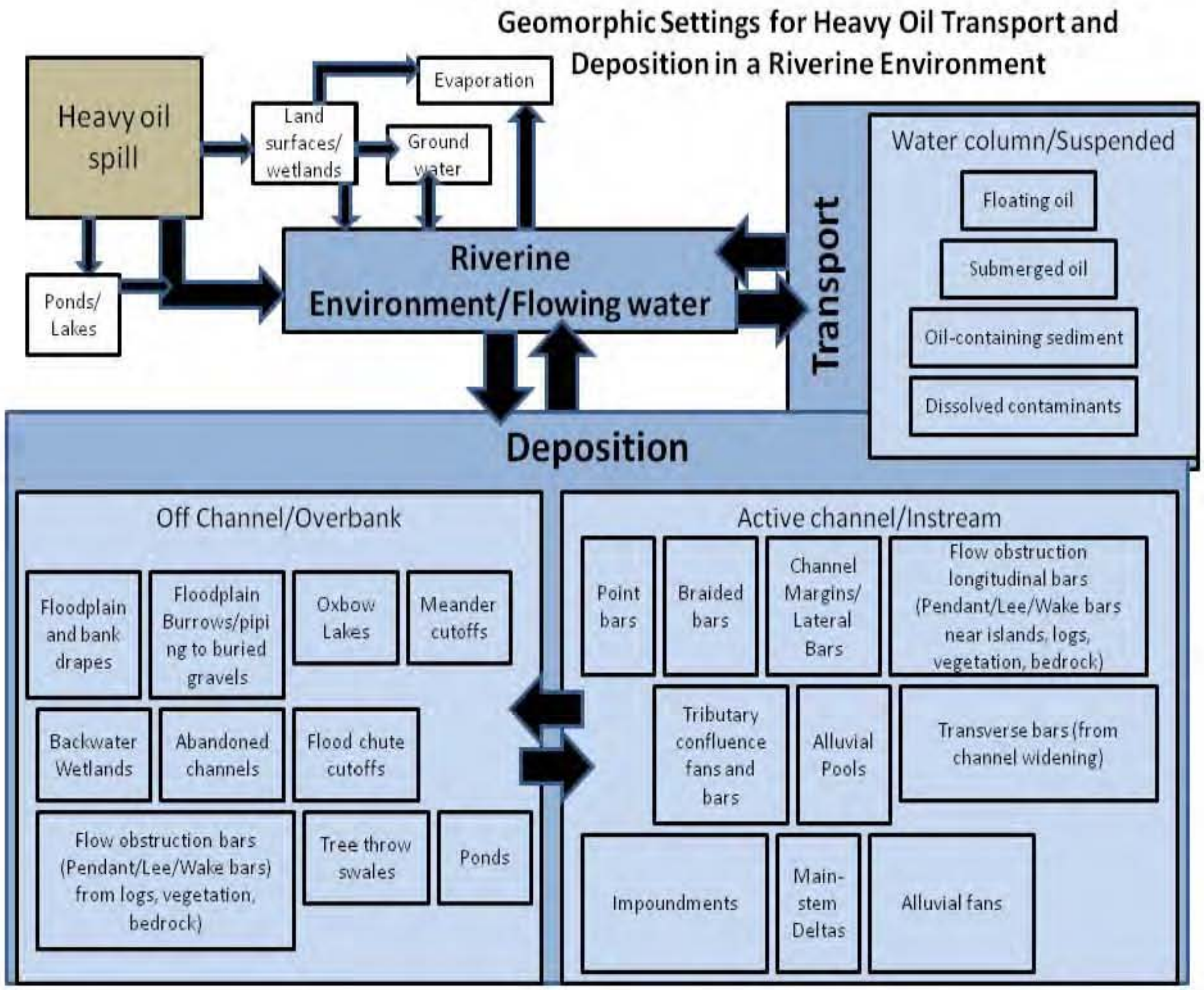


Figure 7.2 Geomorphic Settings for Heavy Oil Transport and Deposition in a Riverine Environment



7.3 Design and Site Selection

Results from 2011 LSR poling and mid- and post- recovery poling activities, along with existing geomorphic knowledge of the river, shall help guide trap locations and specific trap design. In addition, the hydrodynamic model shall be used to help guide selection of locations and to test proposed designs.

The SOSG and CSG shall provide recommendations of locations and design for the sediment collection techniques, to be guided by the following:

- Evidence of re-deposition of submerged oil following recovery;
- Amount and nature of submerged oil;
- Geomorphic setting, including location of major depositional areas;
- Location outside of sensitive habitat areas;
- Proximity to existing access paths for cleanout and monitoring;
- Safety of the public and workers;
- Utility for eventual habitat improvement; and
- A review of appropriate literature relating to techniques successfully implemented in similar settings on other rivers.

The development, design, and location selection of the enhanced sediment collection techniques shall begin in Fall 2011 and continue into 2012 in consultation with the SOSG and CSG. Sediment traps may be installed during the winter months under frozen conditions if appropriate. Structures shall be designed, permitted (as necessary), and installed for longer term maintenance and presence until oil recovery is completed. Devices and locations will be selected to maximize sediment trapping effectiveness and efficiency while minimizing harm to benthic organisms, mussels, fish, amphibians, turtles, mammals, and birds (including diving ducks). In addition, such devices will be implemented in such a way as to minimize barriers to fish passage and to minimize river navigation hazards and obstructions, while still remaining effective and efficient in the primary objective of less intrusive recovery of remaining submerged oil. Consideration will be given to devices that provide habitat diversity and bank protection.

An addendum to this Work Plan shall be provided to the U.S. EPA and USGS that outlines the location and design of each sediment trap. The addendum shall specify any additional field investigation or modeling work deemed necessary to complete the location evaluation and/or the design, and shall include a schedule for completing the evaluation and design tasks. The addendum shall also include a schedule and scope for operations and maintenance of the device(s).

8.0 SCHEDULE

A schedule is presented (Attachment F) for general scheduling purposes only and shall be modified based on numerous factors including river conditions, access, permitting, re-prioritization of areas and the U.S. EPA approval. Updates to the schedule shall be ongoing throughout the project and shall be presented to the U.S. EPA, USGS and MDEQ as needed to indicate significant change.

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