Enbridge Line 6B MP 608 Pipeline Release

Marshall, Michigan

Supplement to the Sampling and Analysis Plan

Referred to as

Work Plan for Evaluating the Potential Impact of

Released Oil on Groundwater used for Drinking Water

Prepared: September 27, 2010

Revised: October 7, 2010

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List of Acronyms

Company – Enbridge Energy, Limited Partnership

HSP – Health and Safety Plan

MDNRE – Michigan Department of Natural Resources and Environment

PAH – Polynuclear Aromatic Hydrocarbons

QAPP – Quality Assurance Project Plan

Response – The initial response to remove oil affected-media and/or sheen affecting and/or posing a risk to navigable water bodies

SAP – Sampling and Analysis Plan

SARCR – Source Area Response Completion Report

SCAT – Shoreline Clean-up Assessment Technique

TDL – Target Detection Limit

U.S. EPA – Unites States Environmental Protection Agency

U.S. FWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

1.0 Introduction

The work proposed is related to Enbridge Energy, Limited Partnership's (the Company's) Line 6B MP 608 spill site in Marshall, Michigan. This work plan is a supplement to the Sampling and Analysis Plan (SAP) revised August 17, 2010 for the Enbridge Line 6B MP 608 Pipeline Release. The purpose of the work is to evaluate the potential short-term and long-term impacts of the released oil on groundwater that has the potential to be a source of drinking water. The work will begin upon submittal of this work plan on September 27, 2010 and will be performed over 35 days as required by the Supplement to Order for Compliance under Section 311(c) of the Clean Water Act signed on September 23, 2010 (September 23, 2010 Supplement to the Order). A report on the work will be submitted on October 31, 2010. The evaluation will generate and utilize information from new groundwater monitoring wells, and will integrate monitoring data that the Company has been collecting. This information includes efforts to identify potable water wells, results from sampling activities that are being performed under the Sampling and Analysis Plan (as amended), the Shoreline Clean-up Assessment Technique (SCAT) process, and characterization and remediation activities for submerged oil.

After the spill, oil migrated down the Kalamazoo River and impacted the shoreline, bank areas, and some overbank upstream of the Morrow Lake Dam. In addition, submerged oil settled in portions of the river bottom upstream from the Morrow Lake Dam. Evaluations performed through the SCAT and through evaluations of river sediments documented the conditions along the river. Oil and oiled material was removed from the system where appropriate under the direction of the U.S. EPA.

An initial conceptual site model has been developed based upon general hydrogeologic principals, well logs available from Michigan's Welllogic database (http://www.michigan.gov/deq/0,1607,7-135-6132_6828-16124--,00.html), and field observations. Along the Kalamazoo River, there is expected to be a layer of glacial drift with permeable sands and gravels that also contains some clay units. This glacial drift unit is underlain by bedrock that includes Marshall Sandstone in the Marshall Formation (Michigan Department of Environmental Quality, Geological Survey Division, 1987). Groundwater

is present in the glacial drift and the underlying bedrock. Many residential wells are screened in the bedrock, while others are screened in the permeable sands and gravels above the bedrock.

The Kalamazoo River's role in the water cycle is that of a conduit through which surface water and groundwater drain to Lake Michigan. Precipitation recharges the groundwater; then groundwater and surface drainage near the river are dominantly expected to flow toward the river. Available regional groundwater flow data (derived primarily from the United States Geological Survey – USGS) along the Kalamazoo River supports the preliminary conclusion that the river is dominantly a gaining river (http://gwmap.rsgis.msu.edu/viewer.htm). However, certain constraints may cause water from the Kalamazoo River to flow into the surrounding sands. Three examples of such constraints are: (1) abrupt increases in the water level of the river during floods which will cause a temporary reversal of the flow, though the annual flow of water would still be toward the river overall; (2) abrupt drops in water levels in the river across dams which can cause localized areas where surface waters flow through the ground around a dam; and (3) high pumping wells located adjacent to the river. The work defined below is designed to evaluate and further develop this initial conceptual site model to address the goals of the work.

2.0 Goals

The goal of this work is to evaluate the potential short- and long-term impacts of the released oil on groundwater with the potential to be a source of drinking water. Potable wells have been identified adjacent to the Kalamazoo River, and groundwater adjacent to the Kalamazoo River has the potential to be used as a source of drinking water. This work will take into account both current and future hydrogeological conditions within the Kalamazoo River, including flooding of the Kalamazoo River. Due to the short duration of the study period as required by the September 23, 2010 Supplement to the Order, this study will develop information related to these conditions that can be directly used in the evaluation of flood conditions. The study will not include direct field readings over periods of flooding from spring melts or targeted high precipitation periods.

This goal will be accomplished through the collection and evaluation of three main categories of activities described further under Work to be Performed:

- Compile and evaluate publically available information;
- Collect and analyze water samples from existing potable water supplies, and
- Collect and evaluate field measurements and laboratory samples from monitoring wells.

3.0 Work to be Performed

The Company will collect additional information to integrate with information from existing and ongoing activities to accomplish the goals of this work plan. The activities to be performed during this work are listed below and detailed in this section.

- Evaluation of publically available information;
- Samples and analysis of water samples from potable water wells;
- Focused hydrogeologic investigation of target areas;
- Evaluation of production wells, and
- Data evaluation and reporting.

The work will be performed using procedures defined by the Sampling and Analysis Plan (SAP) with the supplements that include this document and the standard operating procedures included in Appendix C and the procedures in the Quality Assurance Plan (QAP).

3.1 Evaluation of Accessible Public Information

The Company will compile, evaluate, and utilize the significant historic data that is available on the hydrology of the Kalamazoo River watershed to assist in the evaluation. Several historical investigations have been performed on the Kalamazoo River watershed, including hydrogeological investigations, stream-channel assessments, and water quality assessments. The reports identified at this time include:

- *Historical and Simulated Changes in Channel Characteristics of the Kalamazoo River, Plainwell to Otsego, Michigan*, C.M. Rachol, F. A. Fitzpatrick, and T. Rossi, USGS, 2005.
- *Kalamazoo River Watershed Hydrologic Study*, D. Fongers, Hydrologic Studies Unit, MDEQ, 2008.
- *Kalamazoo River Assessment*, J.K. Wesley, MDNR Fisheries Div., Special Report Publication 35, 2005

- *Kalamazoo County: Geology and the Environment*, Department of Geology, Western Michigan University, Edit. R.N. Passero., *1978*
- *Ground-water Hydrology and Glacial Geology of the Kalamazoo Area, Michigan*, M. Deutsch, K.E. Vanlier, and P.R. Giroux, United States Dept. of Interior Geological Survey, 1960.

In addition, the Company will perform a Freedom of Information Act search of various environmental sites along the Kalamazoo River. Sites along the area of interest will initially be identified using the Michigan Environmental Mapper (http://www.mcgi.state.mi.us/environmentalmapper/). The Company will work with the Kalamazoo District office of the Michigan Department of Natural Resources and Environment to identify additional relevant sites where groundwater investigations have been performed adjacent to, or near, the Kalamazoo River and to gain access to the appropriate reports on these sites in a timely fashion within the schedule constraints required by the September 23, 2010 Supplement to the Order.

USGS observation wells are also located along the Kalamazoo River and provide historical water level data and hydrographs. These data will be reviewed and used as needed for the investigation report. A USGS hydrograph (1987 to 2005) from a well near the mouth of Morrow Lake, shows that water levels ranged from 5.5 to 13.5 feet below ground surface, indicating considerable groundwater fluctuation immediately upstream from Morrow Lake (Appendix B). The Company will further research available resources to assist in the development of hydrological conditions.

3.2 Direct Samples of Potable Water Wells

The Company has been sampling potable water wells located within 200 feet of the Kalamazoo River. An effort has been underway since the spill to identify potable wells, and then collect samples from these potable wells. This effort will continue under a separate supplement to the Sampling and Analysis Plan. Information on the actual groundwater chemistry in these potable wells is a direct line of evidence regarding the documented short-term impacts of the released oil on groundwater that is a

source of drinking water near the Kalamazoo River, and the results from the potable well sampling will be incorporated into this evaluation.

3.3 Focused Hydrogeologic Investigation of Target Areas

A hydrogeologic evaluation will be performed at target areas along the Kalamazoo River to provide direct measurements to test the conceptual site model and evaluate groundwater flow along the Kalamazoo River. The target areas have been selected based on river conditions, hydrogeologic principals, and the distribution of oils observed during the SCAT process and submerged oil investigations. The investigations in each target area are designed to accomplish the following goals:

- Determine if the Kalamazoo River is gaining or loosing at each target area;
- Determine if the quality of groundwater that may act as a source of drinking water is impacted by released oil;
- Generate information on the hydrogeologic conditions along the Kalamazoo River such as the direction of hydraulic gradients and the permeability of the aquifer at the river;
- Provide monitoring wells for water quality sampling and for measurement of hydraulic gradients that can be used for longer term monitoring, and
- Provide direct measurements on typical areas and areas with certain features that will generate data representative of broader sections of the river.

This section describes the selected target areas and then the hydrogeologic investigations that will be performed.

3.3.1 Target Areas

Target areas have been identified for focused hydrologic evaluations using the following criteria:

1. Identified presence of pooled or submerged oil;

2. Locations identified as being potentially losing stream areas along the Kalamazoo River due to changes in hydraulic head (such as at the Ceresco Dam);

3. Locations identified where gaining conditions may be less pronounced associated with tighter meanders in the river, and

4. Additional areas to further refine the conceptual site model.

Four target areas were selected where submerged oil has been identified along sections of the Kalamazoo River where it is expected to be a gaining river. In these areas, the focused investigations will both refine the general conceptual site model of groundwater discharging to the river and also provide direct analysis of groundwater samples to document potential impact on the groundwater from the submerged oil.

The Ceresco Dam area is an individual target area due to the change in the water level across the face of the dam and the potential for this abrupt change in hydraulic head along the river to cause groundwater to flow around the dam. With the dam structure present, there is a potential for groundwater to flow around the edges of the dam a short distance away from the river before re-entering the river below the dam.

One additional target area is provided away from any submerged oil to further test the conceptual site model near the confluence of Talmadge Creek with the Kalamazoo River.

Finally, two target areas are located on tight meanders within the Kalamazoo River. Inside these tight meanders, groundwater is still expected to rise up from lower formations, but shallow groundwater flow may be more parallel to the overall direction of the river flow and may undercut the meanders.

The target areas are shown in Appendix A and are presented below. Each area is defined as a reach of the river, and the actual location of the transects will be selected based upon site conditions and ability to access the appropriate drilling locations in the field.

Target Area	Mile Post Range	Purpose	Wells
1	2.5 to 3.25	Confirm conceptual site model (south side)	3
2	5.5 to 6	Evaluate flow at Ceresco Dam on both sides of river and confirm conceptual site model on both sides of the river	9
3	15 to 15.5	Confirm conceptual site model (east side) and evaluate submerged oil	3
4	22.5 to 23	Confirm conceptual site model (north side) and evaluate submerged oil	3
5	26.5 to 27.25	Evaluate bend	3
6	34.25 to 34.75	Evaluate bend	3
7	36 to 36.25	Confirm conceptual site model (south side) and evaluate submerged oil	3
8	36.75 to 37.25	Confirm conceptual site model (south side) and evaluate submerged oil	3

At each area designed to confirm the conceptual site model, a three-well monitoring system will be installed that will document the vertical and horizontal gradient near the edge of the river. Two monitoring wells will be installed into the glacial drift at nearly the same elevation in a line extending away from the edge of the river. The difference in the elevation of the groundwater between these two monitoring wells will be used to document whether the hydraulic gradient has a horizontal component going toward or away from the Kalamazoo River. The third well at each location will be installed at least 15 feet below one of these drift wells, herein after referred to as a "deep monitoring well". This third well will be used to document whether the hydraulic gradient has an upward or downward component at the well cluster.

At the Ceresco Dam, two sets of the three-well monitoring systems will be installed to document groundwater flow near the dam and an additional three drift wells will also be installed to further refine the groundwater flow path near the dam (nine wells total).

To evaluate bends in the river at the target areas, one three-well monitoring system will be installed within the bend to document the vertical gradient and to document groundwater chemistry within the bend.

3.3.2 Monitor Well Installations

Sonic drilling technologies will be used to install the deep monitoring wells as resources allow. Sonic drilling allows for continuous observation of soil cores, a reduced volume of soil cuttings, and the ability to penetrate into the bedrock if it is reached. Soils will be logged by a trained technician, geologist, scientist or engineer using the Unified Soil Classification System. The locations of the wells will be selected to document the hydraulic gradient adjacent to the Kalamazoo River, to provide water samples representative of the groundwater that may be used as a source of drinking water adjacent to the Kalamazoo River, to accommodate site access constraints which include site features and land owner requirements and preferences, and to allow for the future access to the wells for monitoring.

The shallow monitoring wells will be installed using sonic, hollow stem auger, or direct push technologies. Screened intervals will be selected to access groundwater from permeable sections of the formations that are logged in the field. The five-foot long screens in the shallow monitoring wells will be set within the ground water table, approximately 1 to 5 feet below the groundwater table surface. This will be done in order to prevent the well screens from drying out during low water table conditions. If a confining layer is encountered, the well screen will not penetrate this layer, and the upper portion of the screen may be above the water table. Deep monitoring wells will be installed with the top of the lower screen at least 15 feet below the bottom of the upper screen. If a confining unit is encountered, an attempt will be made to set the lower screen below the aquitard with the annular space in the aquitard completely grouted and the upper screen set above the aquitard.

The monitoring wells will be constructed of 2-inch diameter, five-foot long, schedule 40 PVC, with factory-slotted (10-slot) screen. The wells will be installed with an annular sand pack and grout surface seal. All monitoring wells will be developed to remove fines from the screen interval. All wells will be located by GPS or surveyed to an established site benchmark, and top of casing elevation determined through survey to the nearest 0.01 foot.

3.3.3 Water-Level Measurements

Water level measurements will be taken from each set of monitoring wells and the surface water on at least three separate days. To achieve the required schedule for this order, water level measurements are not expected to occur during significant precipitation events or during spring snow melts.

3.3.4 Slug-Testing

Slug-testing will be performed on one shallow and one deep monitoring well in each of the target areas. These slug tests are intended to provide further information in support of the conceptual site model for future work, and will be performed according to SOP GW5 in Appendix C. Slug-testing data will be recorded using in-situ pressure transducers and recorded on a data logger. Data will be analyzed using commercially-available curve matching software and applicable hydrogeological solutions (Bouwer and Rice, 1976; or other).

3.3.5 Water Sample Collection and Analysis

Groundwater samples will be collected using Low-Flow Minimum Drawdown techniques as described by Puls & Barcelona (1996) as defined in the Sampling and Analysis Plan. Groundwater samples will be collected in sampling vessels and analyzed as described in the Sampling and Analysis Plan (SAP). Groundwater samples will be collected a minimum of three days after well development. Groundwater samples will be analyzed for the parameters in Table 1.

One surface water sample will be collected in each target area. Surface water samples will be collected adjacent to the river bank, near the monitoring wells in each target area using a peristaltic pump and disposable tubing. Surface water samples will be placed directly into analytical sample bottles. These samples e analyzed for the following parameters: calcium, magnesium, sodium (major cations), and chloride, sulfate, and bicarbonate (major anions), as well as the water quality parameters temperature, specific conductivity, turbidity, pH and oxidation-reduction potential. Surface water sampling will be conducted in accordance with SOP 2010-4 of the SAP.

These surface water sample collection locations will be surveyed for x and y position using the GPS system, in the same coordinate system as the monitoring well locations as is discussed in section 3.3.2..

This water sample collection and analysis is recommended to further evaluate potential zones where surface water is venting to groundwater (James, 2002). The major element analyses will be used to construct stiff diagrams, tri-linear diagrams or simpler x-y graphs that show relationships between the chemistry of the river water and the groundwater. To support this analysis, samples of the river water will be collected and analyzed for major element chemistry.

The scheduled analyses of water samples are summarized in Table 1. Due to the limited duration of this study, only one round of groundwater samples will be collected from the monitoring wells as a part of this work plan.

3.3.6 Sampling and Analysis Plan

A SAP has been developed that presents the methods and operating procedures that will be used for all investigations at the site. The plan documents procedures such as sampling, analytical methods, decontamination, sample preservation and shipping, chain of custody, field documentation, instrument calibration, management of investigation derived waste, etc.

3.4 Evaluation of Production Wells

The Company will identify production wells which have the potential to create more drawdown and affect groundwater flow near the river. This list will be generated by reviewing the location database obtained as part of the ongoing potable water well evaluation described in Section 3.2. Municipal well fields will be addressed by contacting the individual municipalities along the study area. If industrial high production wells are identified, pumping from these wells will also be researched. The report will include a presentation of the wells identified and the potential impact on groundwater flow patterns and recommendations.

3.5 Data Evaluation and Reporting

Data will be added to an EPA SCRIBE database routinely and updated as samples are collected and validated data is received. The local project will be uploaded to scribe.net. The results of the work specified in this work plan will be presented in a written report. The report will include an introduction, objectives, methods, data evaluation, sample location map, cross sections with water levels, data tables, sample location coordinates, data interpretation, and a summary. Deviations from

the work plan will be identified and reasons for the deviations will be presented. For example, well locations may need to be adjusted based on field conditions. Cross sections at key locations will be included to illustrate stratigraphy, permeable zones and groundwater potentiometric information.

4.0 Schedule

Performance of this work plan began on September 27 concurrent with submittal of the work plan. Procurement and scheduling of vendors such as drillers is the first task, and the actual schedule will need to be adjusted based upon availability of equipment such as drill rigs to perform the work. To meet the schedule requirements mandated in the September 23, 2010 Supplement to the Order, the schedule for this project will overlap tasks and run multiple tasks in parallel schedules. As drilling is complete on a set of wells, groundwater sampling will be scheduled to begin rapidly following the required rest time for the wells after development.

Collection and interpretation of publically available information	27-Sep through 26-Oct
Potable well sampling	On-going
Procurement and planning / mobilize drilling equipment	27-Sep through 3-Oct
Access agreements and utility clearance	27-Sep through 15-Oct
Drilling, monitoring well installation and development	4-Oct through 19-Oct
Well sampling	8-Oct through 22-Oct
Laboratory analysis of water samples	9-Oct through 26-Oct
Survey well locations	11-Oct through 24-Oct
Water level measurements and recording	11-Oct through 26-Oct
Data interpretation	6-Oct through 29-Oct
Report preparation	10-Oct through 31-Oct
Submit final report	31-Oct

5.0 References

Bouwer, H. and R.C. Rice, 1976. "A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells." Water Resources Research, vol. 12, no. 3, pp. 423-428.

Rachol, C.M, F. A. Fitzpatrick, and T. Rossi, 2005, *Historical and Simulated Changes in Channel Characteristics of the Kalamazoo River, Plainwell to Otsego, Michigan*, USGS.

Fongers, D. 2008, *Kalamazoo River Watershed Hydrologic Study*, Hydrologic Studies Unit, MDEQ.

Drever, James I. *The Geochemistry of Natural Waters, Surface and Groundwater Environments*, Third Edition. Upper Saddle River, NJ: Prentice Hall, 2002.

Deutsch, M., K.E. Vanlier, and P.R. Giroux, *1960. Ground-water Hydrology and Glacial Geology of the Kalamazoo Area, Michigan*, United States Dept. of Interior Geological Survey.

Enbridge, 2010a. Enbridge Line 6B MP 608 Pipeline Release Marshal, Michigan Source Area Response Completion Report. (August 31, 2010 revision).

Michigan Department of Environmental Quality, Geological Survey Division, 1987. "1987 Bedrock Geology of Michigan"
http://www.michigan.gov/documents/deq/1987_Bedrock_Geology_Map_301466_7.pdf

Puls, R.W. and M.J. Barcelona, 1996, *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedure*, EPA/540/S-95/504, 12 pp. (http://www.epa.gov/tio/tsp/download/lwflw2a.pdf)

Wesley, J.K., *2005, Kalamazoo River Assessment*, MDNR Fisheries Div., Special Report Publication 35.

Appendix A

Target Areas

Appendix B

Historical USGS Hydrograph

Showing Water Table Fluctuation Near Morrow Lake

Appendix C

Standard Operating Procedures

Table