Attachment A

Remedial Investigation Report for Reach 3

Enbridge Line 6B MP 608

Marshall, MI Pipeline Release

Remedial Investigation Report for Reach 3

Prepared for Michigan Department of Environmental Quality

Enbridge Energy, Limited Partnership

Submitted: October 30, 2014

Document ID 3769

Table of Contents

Executive Summary……....1

1.0 Introduction 5

1.1 Purpose and Scope 5

1.2 Line 6B Crude Oil Release Scenario 6

1.3 Project Timeline 7

1.4 Reach 3 Location and Land Use 8

1.5 General Hydrology and Geology of Talmadge Creek and Kalamazoo River Valley 9

1.6 Line 6B Crude Oil Composition 12

2.0 Project Background 15

2.1 Initial Response Activity 17

2.2 Shoreline Cleanup and Assessment Technique Activities 17

2.3 Submerged Oil Task Force Activities 18

2.4 Shoreline and Overbank Re-assessment Technique 19

2.5 Remedial Actions 21

2.6 Talmadge Creek Remedial Investigation 21

2.7 Potable Wells 22

3.0 Investigative Methods 23

3.1 Soil Borings and Sample Characterization 24

3.1.1 Manual Borings 24

3.1.2 Direct Push Drilling 25

3.1.3 Soil Core/Sample Characterization 25

3.2 Temporary Well Installation and Sampling 27

3.2.1 Temporary Well Construction and Installation 27

3.2.2 Temporary Well Sampling 27

3.3 Cleanup Criteria and Screening Levels 28

3.3.1 Human Health 28

3.3.2 Terrestrial 29

3.4 Analytical Program.....29

3.4.1 Analytical Parameters.....29

3.4.2 QA/QC Evaluation 30

3.4.3 Elevated Reporting Limits.....33

3.4.4 MDEQ Split Samples.....34

3.4.5 Evaluation of Metals Associated with Line 6B Crude Oil.....35

3.5 Additional Studies 36

3.5.1 Fluorescent Light Detection and Ranging System and Polarimetric Imagery.....36

3.5.2 Light Detection and Ranging 37

3.5.3 High-Resolution Aerial Photography 37

3.5.4 Field Screening Techniques.....37

3.6 Waste Management 38

4.0 Investigation Activities and Results 39

4.1 Talmadge Creek Response Activities (2010) 39

4.1.1 Talmadge Creek Response Excavation (2010).....39

4.1.2 Talmadge Creek 2010 Post Excavation Assessment 40

4.1.3 2010 Auxiliary Location Post-Excavation Assessment.....41

4.1.4 Talmadge Creek Response Activities Conclusion.....42

4.2 2011 Shoreline and Overbank Re-assessment Technique on Talmadge Creek .43

4.2.1 Shoreline and Overbank Re-assessment Technique Results – Left Descending Bank 44

4.2.2 Shoreline and Overbank Re-assessment Technique Results – Right Descending Bank 44

4.3 Talmadge Creek Remedial Investigation.....44

4.3.1 Soil Analytical Results 45
4.3.2 Sediment Analytical Results 46
4.3.3 Groundwater Analytical Results 47
4.3.4 Surface Water Results.....48
4.4 Talmadge Creek Excavation (2011 – 2012) 48
4.4.1 Soil Analytical Results 50
4.4.2 Groundwater Analytical Results 51
4.4.3 2013 Auxiliary Location Post-Excavation Assessment.....51
4.5 2014 Data Gap Assessment.....52
4.5.1 Visual Surficial Observations.....52
4.5.2 Trace Ultraviolet Fluorescence Sampling.....53
4.5.3 Ultraviolet Fluorescence Sampling 55
4.5.4 VOC and PNA Exceedance Verification Sampling.....57
4.5.5 2011 Excavation Delineation Sampling 58
4.5.6 Wolverine and Panhandle Pipeline Sampling.....59
4.5.7 Elevated Reporting Limits.....60
4.5.7.1 Elevated Reporting Limit Evaluation Process 60
4.5.7.2 Elevated Reporting Limits – Individual Evaluation 62
4.5.7.3 Elevated Reporting Limits – Data Gap Investigations.....62

5.0 Reach 3 Results and Exposure Evaluation 63
5.1.1 Control of Hazardous Substance Sources 63
5.1.2 Groundwater Contamination Risks to Drinking Water Uses.....63
5.1.3 Groundwater Contamination Risks for Indoor Air Hazards.....64
5.1.4 Groundwater Contamination Risks of Hazard to Surface Water Resources 64
5.1.5 Soil Contamination Risks from Direct Contact Exposure 64
5.1.6 Soil Contamination Risks from Ambient Air Inhalation Exposures 65
5.1.7 Soil Contamination Risks from Indoor Air Inhalation Exposures 65
5.1.8 Soil Contamination Risks from Inhalation of Particulates Exposures 65

5.1.9 Soil Contamination Risk of Injury to Drinking Water Uses of Groundwater 65
5.1.10 Soil Contamination Risk for Groundwater to Pose Risk to Surface Water 66
5.1.11 Risk of Contaminated Soils Runoff to Surface Waters 67
5.1.12 Acute Toxic and Physical Hazard Risks 67
5.1.13 Aesthetic Impacts 67
5.1.13.1 Surface Water Aesthetic Evaluation 68
5.1.13.2 Groundwater Aesthetic Evaluation.....69
5.1.13.3 Soil Aesthetic Evaluation 69
5.1.13.4 Aesthetics Conclusion.....70
5.1.14 Terrestrial Evaluation.....70
5.1.15 Other Hazardous Substance Risks at or Posed by the Property.....71
5.2 Proposed and Completed Remedial Actions 71

6.0 Summary and Conclusions.....72

6.1 Summary of Remedial Activities and Investigations 72
6.1.1 Talmadge Creek Response Excavation (2010).....72
6.1.2 2011 Shoreline and Overbank Re-assessment Technique on Talmadge Creek 72
6.1.3 Talmadge Creek Remedial Investigation.....73
6.1.4 Talmadge Creek Excavation (2011–2012) 74
6.2 Conclusions 74
6.2.1 Soil.....75
6.2.2 Sediment 75
6.2.3 Groundwater.....76
6.2.4 Surface Water.....77

7.0 References.....78

FIGURES

Figure 1 **Reach 3 Site Location**

Figure 2 **Reach 3 Geologic Cross Sections**

Figure 3 **Reach 3 Potable Well Locations**

Figure 4 **Reach 3 All Sampling Locations**

Figure 5 **Reach 3 Spring 2011 SORT Reassessment**

Figure 6 **Reach 3 2010 U.S. EPA Clearance Areas and 2010 Post-Excavation Assessment Soil Samples**

Figure 7 **Reach 3 Decommissioning/Auxiliary Locations 2010 and 2013**

Figure 8 **Reach 3 Soil Sample and Core Locations**

Figure 9 **Reach 3 Sediment Core Locations and Poling Locations**

Figure 10 **Reach 3 Groundwater and Surface Water Sample Locations**

Figure 11 **Reach 3 Data Gap Sample Locations 2013 – 2014**

TABLES

Table 1 **Reach 3 Potable Water Analytical Data**

Table 2 **Reach 3 Post-Excavation Soil Analytical Data – 2010**

Table 3 **Reach 3 Unsaturated Soil Analytical Data – TCRI 2011 - 2014**

Table 4 **Reach 3 Saturated Soil Analytical Data – TCRI 2011 - 2014**

Table 5 **Reach 3 Soil SPLP Analytical Data – TCRI 2011 - 2014**

Table 6 **Reach 3 Sediment Analytical Data**

Table 7 **Reach 3 Groundwater Analytical Data– TCRI 2011 - 2014**

Table 8 **Reach 3 Surface Water Analytical Data– TCRI 2011 - 2014**

Table 9 **Reach 3 Unsaturated Soil Analytical Data – Post-Excavation 2011 - 2012**

Table 10 **Reach 3 Saturated Soil Analytical Data– Post-Excavation 2011 - 2012**

Table 11 **Reach 3 Soil SPLP Analytical Data – Post-Excavation 2011 - 2012**

Table 12 **Reach 3 Groundwater Analytical Data – Post-Excavation 2011 - 2012**

Table 13 **Reach 3 Soil Analytical Data – Decommissioning / Auxiliary Locations – 2013**

Table 14 **Reach 3 Potential Aesthetic Observations**

ATTACHMENTS

Attachment A **Legal Descriptions**

Attachment B **Standard Operating Procedures**

Attachment C **2011 SORT**

Attachment D **Photograph Logs and Boring Logs**

Attachment E **Low Flow Groundwater Sampling Forms**

Attachment F **Level 1 Data Review Memoranda**

Attachment G **White Paper: Evaluation of Metals in Soil and Groundwater**

Attachment H **Fluorescent Light Detection and Ranging System, Light Detection and Ranging, and Polarimetric Image Reports**

Attachment I **Laboratory Data**

LIST OF ACRONYMS AND DEFINITIONS

bgs	below ground surface
Criteria (Criterion)	Part 201 Residential Generic Cleanup Criteria (Criterion)
CSM	*Conceptual Site Model*, submitted to the MDEQ on July 8, 2011
CSM-2013	*Conceptual Site Model – 2013*, submitted to the MDEQ on April 25, 2013
CSM-2014	*Conceptual Site Model – 2014*, submitted to the MDEQ on July 25, 2014
CL	Cold Lake Blend
cm	Centimeter
CWA	Clean Water Act
DCC	Part 201 Generic Residential Direct Contact Criteria
DWC	Part 201 Generic Residential Drinking Water Criteria
DWPC	Part 201 Generic Residential Drinking Water Protection Criteria (for soils)
ECB	Erosion Control Blanket
Enbridge	Enbridge Energy, Limited Partnership
ERL	Elevated Reporting Limit
Field Guide	*Field Guide for Soil and Stratigraphic Analysis v.2*
FLS	Fluorescent Light Detection and Ranging System
ft	Feet
GPS	Global Positioning System
GSIC	Part 201 Generic Residential Groundwater Surface Water Interface Criteria
GSIPC	Part 201 Generic Residential Groundwater Surface Water Interface Protection Criteria (for soils)
GVIAIC	Part 201 Generic Residential Groundwater Volatilization to Indoor Air Inhalation Criteria
HP OSCAR	High Priority Outstanding Sites Characterization and Reconciliation
I	Island
I-69	Interstate 69
Inundation Area	Area where overflow water extended beyond the river bank
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LDB	Left Descending Bank
LIDAR	Light Detection and Ranging
LIF	Laser Induced Fluorescence
Line 6B	The pipeline owned by Enbridge Energy, Limited Partnership that runs just south of Marshall, Michigan
MDEQ	Michigan Department of Environmental Quality
MDEQ Order	Administrative Consent Order And Partial Settlement Agreement entered *In the Matter of Enbridge Energy Partners, L.P., and Enbridge Energy, Limited Partnership*, proceedings under the Michigan Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, MCL 324.101 et seq. signed November 1, 2010
Metals White Paper	*White Paper: Evaluation of Metals in Soil and Groundwater,* submitted to the MDEQ on June 4, 2014
mg/kg	milligrams per kilogram

MP	Mile Post, used to identify the affected portions of Talmadge Creek and the Kalamazoo River. Mile Posts begin where the Line 6B release entered Talmadge Creek, MP 0.00 and extend downstream to the Morrow Reservoir (MP 39.85).
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAPL	Non-Aqueous Phase Liquids
NOAA	National Oceanic and Atmospheric Administration
O&M	Operations and Maintenance
OOR	Overbank Oil Recovery
OSCAR	Outstanding Sites Characterization and Reconciliation
Part 201	Part 201 of Michigan's Act 451 of 1994, as amended
%R	Percent Recovery
PI	Polarimetric Imagery
PID	Photoionization Detector
PNAs	Polynuclear Aromatic Hydrocarbons
Polygon	In ArcGIS software, a closed shape defined by a connected sequence of x,y coordinate pairs used to record a field observation.
ppm	parts per million
PSIC	Part 201 Generic Particulate Soil Inhalation Criteria
PVC	Polyvinyl Chloride
PVOCs	Petroleum Volatile Organic Compounds
QAPP	*Quality Assurance Project Plan (QAPP),* submitted to the MDEQ on August 19, 2011
QA/QC	Quality Assurance/Quality Control
R5 ESLs	U.S. EPA Region 5 Ecological Screening Levels
RDB	Right Descending Bank
Reach 3	A subset of the Spill Area that includes slightly more 0.5 miles of Talmadge Creek downstream of Division Drive, MP 0.50 – MP 1.00, ending at Interstate 69
RI	Remedial Investigation
RIWP	*Remedial Investigation Work Plan for Talmadge Creek from MP 0.50 to 2.25,* submitted to the MDEQ on September 15, 2011
RIWP Supplement	*Talmadge Creek Remedial Investigation Work Plan MP 0.50 – 2.25, Supplement: Additional Investigation of Impacted Areas*, submitted to the MDEQ on December 28, 2011
RLs	Reporting Limits
S^3TM	*MDEQ Sampling Strategies and Statistics Training Materials (S^3TM) for Part 201 Cleanup Criteria,* issued August 2002.
SAP	*Sampling and Analysis Plan (SAP),* submitted to the MDEQ on August 30, 2011
SAR	*Source Area Response Plan,* submitted to the U.S. EPA on August 19, 2010
SCAT	Shoreline Cleanup and Assessment Technique
SOP	Standard Operating Procedure
SORT	Shoreline and Overbank Reassessment Technique
SOTF	Submerged Oil Task Force

Source Area	A Subset of the Spill Area that encompasses the pipeline breach and approximately 5 acres of land where the Line 6B crude oil release emerged onto the ground surface.
Spill Area	A Facility created by the July 2010 release of oil from the Enbridge Line 6B pipeline located at or near 16000 Division Drive in Marshall, Michigan, and also areas, places, or property that have been disturbed, destroyed, or otherwise altered as a result of the oil spill or response activities taken to address the oil spill, including but not limited to habitat, vegetation, surface waters, soils, sediments, groundwater, wetlands, floodplains, and overbank areas.
SPLP	Synthetic Precipitation Leaching Procedure
SSAR	*Supplemental Source Area Response Plan,* submitted to the U.S. EPA on October 17, 2010
START	Superfund Technical Assessment and Response Team
Supplemental Order	Supplement to Order for Compliance Under Section 311(c) of the Clean Water Act, issued by U.S. EPA Region 5 on September 23, 2010 to Enbridge Energy Partners, L.P. *et al*., Respondents, Docket No: CWA 1321-5-10-001
SVIAIC	Part 201 Generic Residential Soil Volatilization to Indoor Air Inhalation Criteria
TCRI	Talmadge Creek Remedial Investigation
TCE	Trichloroethylene
TDLs	Target Detection Limits
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
ug/kg	micrograms per kilogram
ug/l	micrograms per liter
USCS	Unified Soil Classification System
U.S. EPA	United States Environmental Protection Agency
U.S. EPA Order	U.S. *EPA Removal Administrative Order Under Section 311(c) of the Clean Water Act*, issued on July 27, 2010 to Enbridge Energy Partners, L.P., Docket Number: CWA 1321-5-10-001
USGS	United States Geological Survey
UV	Ultraviolet
VOCs	Volatile Organic Compounds
VSIC	Part 201 Generic Residential Soil Ambient Air Infinite Source Volatile Soil Inhalation Criteria
WCS	Western Canadian Select

Executive Summary

This executive summary presents an overview of the background, remedial and investigation activities, and conclusions of the Remedial Investigation conducted on the Reach 3 segment of Talmadge Creek. The Reach 3 segment encompasses the portion of Talmadge Creek starting from Mile Post 0.50 at Division Drive through the first portion of Mile Post 1.25, ending at Interstate 69, as depicted on *Figure 1*. This Remedial Investigation report is organized into seven sections as follows:

1. Introduction,
2. Project Background,
3. Investigative Methods,
4. Investigation Activities and Results,
5. Reach 3 Conditions and Exposure Evaluation,
6. Summary and Conclusions, and
7. References.

On July 26, 2010, Enbridge Energy, Limited Partnership discovered a release of crude oil from the Line 6B pipeline owned by Enbridge Energy, Limited Partnership that is located just south of Marshall, Michigan. The Line 6B crude oil was released below grade via a break in Line 6B at pipeline Mile Post 608. The Line 6B crude oil subsequently emerged at the ground surface and flowed over land, following the natural topography into Talmadge Creek. The Line 6B crude oil entered Talmadge Creek at a point designated as Mile Post 0.00 and flowed down the creek to the confluence with the Kalamazoo River and subsequently down the Kalamazoo River.

The Spill Area was defined by the Michigan Department of Environmental Quality as “a Facility created by the July 2010 release of oil from the Enbridge Line 6B pipeline located at or near 16000 Division Drive in Marshall, Michigan, and also areas, places, or property that have been disturbed, destroyed, or otherwise altered as a result of the oil spill or response activities to address the oil spill, including but not limited to habitat, vegetation, surface waters, soils, sediments, groundwater, wetlands, floodplains, and overbank areas”. All Remedial Investigation activities were completed pursuant to the pertinent rules and regulations included in Part 201 of Michigan’s Act 451 of 1994, as amended.

The objectives of the Reach 3 Remedial Investigation were to:

- Characterize the nature and extent of contaminants in soil, sediment, groundwater, and surface water associated with the Line 6B crude oil release and subsequent response activities.
- Confirm the effectiveness of the response activities.
- Identify and evaluate potential migration pathways.
- Assess risks to human health, potential terrestrial risks, and potential aesthetic impacts.
- Build upon the principles established in the approved *Conceptual Site Model*, which was developed by Enbridge Energy, Limited Partnership and submitted to the Michigan Department of Environmental Quality on November 30, 2010 and subsequently updated in 2013 and 2014.

Enbridge Energy, Limited Partnership completed several phases of Remedial Investigation activities pursuant to these objectives, including the sampling and analysis of multiple media types (soil, sediment, groundwater, and surface water), the implementation of advanced investigative technologies (Polarimetric Imaging, Fluorescent Light Detection and Ranging System, high resolution ultraviolet photography/logging, and high resolution aerial photography), the assessment of potential human health and terrestrial risks, and the evaluation of potential aesthetic impacts. The Remedial Investigation fieldwork within Reach 3 was conducted in multiple phases from August 2011 through and including March 2014. This phased approach allowed for focused data collection, with each phase building upon the previous phase of investigation and the principles in the Conceptual Site Model, while addressing on-going data gaps.

Analytical results from the Remedial Investigation soil sampling revealed that two volatile organic compounds, chloromethane and trichloroethylene, were detected above Part 201 Residential Generic Cleanup Criteria. However, chloromethane is a highly volatile gas that was not detected in Line 6B crude oil. In addition, 39% of the chloromethane detects were associated with laboratory blank detections. As a result, it is presumed that chloromethane detections are laboratory artifacts. Trichloroethylene was not detected in Line 6B crude oil; however, it may or may not be related to response activities completed in the Spill Area. Notably, the location of this trichloroethylene detection in soil exceeding the Drinking Water Protection Criteria is adjacent to a utility corridor, which makes it possible that the source is

related to other historic work completed in the area. Further investigation of the groundwater beneath this low level detection of trichloroethylene in unsaturated soil has demonstrated no potential risk to human health since the groundwater sample result was below Part 201 Residential Groundwater Generic Cleanup Criterion. Analytical results from Remedial Investigation soil, sediment, groundwater, and surface water sampling indicate that there were no volatile organic compounds or polynuclear aromatic hydrocarbons detected above the Part 201 Residential Generic Cleanup Criteria in Reach 3.

Results from the TCRI were used to develop the 2011 and 2012 excavation boundaries. Extensive excavation activities took place from November 2011 through and including early March 2012, removing oil-impacted soil and sediment. The streambed sediments, several selected overbank areas, and portions of the adjacent wetland were excavated. Analytical results from the 2011-2012 post-excavation soil verification sampling reveal that although two volatile organic compounds, chloromethane and toluene, were detected above Part 201 Residential Generic Cleanup Criteria, there was only one exceedance (toluene exceeding the Groundwater Surface Water Interface Protection Criteria in unsaturated soil sample location ESTC0100R154) by a volatile organic compound associated with the Line 6B crude oil. The other compound, chloromethane, was determined to be a laboratory contaminant as discussed above. The groundwater beneath the low-level toluene detection in soil was further investigated and demonstrated that no risk to human health exists since the groundwater sample was below Part 201 Residential Groundwater Generic Cleanup Criterion. Analytical results from groundwater samples collected during the 2011-2012 excavation activities show there were no Part 201 Residential Generic Cleanup Criteria exceedances by volatile organic compounds or polynuclear aromatic hydrocarbons in any of the groundwater samples. Analysis of decommissioning soil samples indicated that no exceedances of Part 201 Residential Generic Cleanup Criteria by site-related compounds were detected.

A compilation and thorough evaluation of analytical data collected to date from environmental media supports the following conclusions regarding impacts to the Reach 3 Spill Area:

- Characterized the full nature and extent of contaminants in soil, sediment, groundwater and surface water associated with the Line 6B crude oil release and subsequent response activities.

- Sufficient data has been collected, analyzed, and evaluated to support the position that no further action is necessary to address human health risks related to soil, sediment, groundwater, and surface water in the Reach 3 Spill Area.

- Enbridge has completed a thorough evaluation of potential terrestrial risks, and based on this evaluation, no terrestrial risks are present with regard to soil within the Reach 3 Spill Area.

- Instances where potential aesthetic impacts have been observed in the Reach 3 Spill Area have dramatically decreased as a result of ongoing remedial efforts and natural degradation. Based on a thorough and comprehensive review of potential aesthetic impact observations in Reach 3, Enbridge has not identified any aesthetic impacts that would require additional evaluation or action.

1.0 Introduction

This portion of the Remedial Investigation (RI) report presents the purpose and scope of the RI, a brief description of the Enbridge Energy, Limited Partnership (Enbridge) Line 6B crude oil pipeline (Line 6B) release, project timeline, description of the location and land uses within Reach 3, and Line 6B crude oil composition.

1.1 Purpose and Scope

The purpose of this RI report is to present a comprehensive summary of the remedial activities conducted at Reach 3. The remedial activities included both excavation/response efforts and investigations/assessments of Reach 3 to address impacts related to the Line 6B crude oil release. This RI report incorporates principles established in the approved *Conceptual Site Model*, submitted to the Michigan Department of Environmental Quality (MDEQ) on July 8, 2011 (Enbridge, 2011a) and subsequently updated as the approved *Conceptual Site Model - 2013* submitted to the MDEQ on April 25, 2013 (Enbridge, 2013a) and as the *Conceptual Site Model – 2014*, submitted to the MDEQ on July 24, 2014 (CSM-2014) (Enbridge, 2014a). The CSM-2014 presents Enbridge's current understanding of the system (oil fate and transport, pathway evaluation, and existing conditions) and relates this understanding to the MDEQ regulatory framework.

The Spill Area was defined by the MDEQ as "a Facility created by the July 2010 release of oil from the Enbridge Line 6B pipeline located at or near 16000 Division Drive in Marshall, Michigan, and also areas, places, or property that have been disturbed, destroyed, or otherwise altered as a result of the oil spill or response activities to address the oil spill, including but not limited to habitat, vegetation, surface waters, soils, sediments, groundwater, wetlands, floodplains, and overbank areas". The Spill Area is thus defined by the Administrative Consent Order and Partial Settlement Agreement entered *In the Matter of Enbridge Energy Partners, L.P., and Enbridge Energy, Limited Partnership*, proceedings under the Michigan Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, MCL 324.101 et seq; issued November 1, 2010 (MDEQ Order) (MDEQ, 2010).

This RI report addresses a subset of the Spill Area, designated as the Reach 3 Spill Area, which includes slightly more than 0.5 miles along Talmadge Creek, downstream of Division Drive. The Reach 3 Spill Area encompasses the portion of Talmadge Creek starting from Mile

Post (MP) 0.50 at Division Drive through the first portion of MP 1.25, ending at Interstate 69 (I-69), as depicted on *Figure 1*.

1.2 Line 6B Crude Oil Release Scenario

On July 26, 2010, Enbridge discovered a release of crude oil from the Line 6B pipeline that is located south of Marshall, Michigan in the vicinity of a pump station. The Line 6B crude oil was released below grade via a break in Line 6B at pipeline MP 608. The Line 6B crude oil subsequently emerged at the ground surface, and flowed over land following the natural topography and into Talmadge Creek. The Line 6B crude oil entered Talmadge Creek at a point designated as MP 0.00 and flowed down the creek to the confluence with the Kalamazoo River, and subsequently moved down the Kalamazoo River.

At the time of the Line 6B crude oil release, Talmadge Creek and Kalamazoo River discharges were higher than normal due to recent heavy rain, and in many areas, the creek and river had overflowed their banks. As water receded, Line 6B crude oil flowed along with the floodwater back into the main body of the creek and river. However, some Line 6B crude oil adhered to existing vegetation or became stranded in hydrologically isolated topographic depressions, cavities, burrows, and other traps within the flooded areas.

Following the Line 6B crude oil release, Enbridge performed response activities under the direction and supervision of the United States Environmental Protection Agency (U.S. EPA) and the MDEQ, to remove Line 6B crude oil from the river system and to respond to the release. A substantial amount of Line 6B crude oil was recovered using booms, vacuum surface pumping, vegetation removal, and extensive excavation in the immediate area of the release (Source Area) and along Talmadge Creek and the Kalamazoo River.

Spill response actions were conducted in accordance with the Administrative Orders issued to Enbridge by U.S. EPA and the MDEQ. These Orders include: the U.S. EPA *Removal Administrative Order Under Section 311(c) of the Clean Water Act* (CWA), issued on July 27, 2010 to Enbridge Energy Partners, L.P., Docket Number: CWA 1321-5-10-001 (U.S. EPA Order); and, the Supplement to Order for Compliance Under Section 311(c) of the CWA, issued by U.S. EPA Region 5 on September 23, 2010 to Enbridge Energy Partners, L.P. *et al*., Respondents, Docket No: CWA 1321-5-10-001 (Supplemental Order) (U.S. EPA, 2010), as well as the MDEQ Order.

1.3 Project Timeline

The following is a general timeline associated with the Line 6B crude oil release and response activities/remedial actions conducted along the Kalamazoo River, Talmadge Creek, and in the Reach 3 Spill Area. This timeline demonstrates not only the extensive level of work performed, but also shows the close coordination between activities. Enbridge routinely used the results of each segment of work conducted during the project to inform and guide work on subsequent efforts.

- July 26, 2010 – Release Date, Enbridge initiates emergency response with recovery of Line 6B crude oil and boom placement on Talmadge Creek and the Kalamazoo River,
- July 27, 2010 – U.S. EPA issues the U.S. EPA Order,
- July 29, 2010 – *Work Plan Enbridge Marshall Pipeline Release,* submitted to the U.S. EPA (Enbridge, 2010a), which addresses oil recovery and containment, source release remediation, downstream remediation, pipeline repair, and sampling and analysis plan,
- August 2, 2010 – *Source Area Response Plan* submitted to the U.S. EPA (Revised August 19, 2010) (SAR) (Enbridge, 2010b),
- August 2010 – Shoreline Cleanup and Assessment Technique (SCAT) activities,
- August 2010 – Initial Talmadge Creek Excavation,
- September 2010 – Post-Response Shallow Soil Assessment Division A, B 2.7 and Post-Response Investigation,
- September 2010 – Submerged Oil Task Force (SOTF) activities conducted along the Reach 3 Spill Area,
- September/October 2010 – Report of Findings for Response Action at the Source Area and initial response excavation activities,
- September/October 2010 – Completion of SAR assessment and excavation activities,
- February 2011 – Laser induced fluorescence (LIF) along Talmadge Creek,
- April 2011 – Shoreline and Overbank Reassessment Technique (SORT) activities,
- April 2011 – Fluorescent Light Detection and Ranging System (FLS) and Polarimetric Imagery (PI) surveys,
- Summer of 2011 - Overbank Oil Recovery (OOR) performed,
- August 2011 – Talmadge Creek RI (TCRI) initiated in accordance with the approved *Remedial Investigation Work Plan for Talmadge Creek from MP 0.50 to 2.25,* submitted to the MDEQ on September 15, 2011 (RIWP) (Enbridge, 2011b) ,

- October 2011 - Talmadge Creek background soil samples collected,
- December 2011 – Approved *Talmadge Creek Excavation Work Plan MP 0.50 - MP 1.00*, submitted to the MDEQ on December 7, 2011 (Enbridge, 2011c),
- January 2012 through and including March 2012 – Excavation and excavation sampling of the Talmadge Creek streambed and overbank areas,
- January 2012 through and including March 2012 – Demobilization of 2011-2012 excavation of auxiliary sites concurrent with excavation activities,
- February 2012 – Approved *Talmadge Creek Excavation Work Plan MP 1.00 – MP 2.25*, submitted to the MDEQ on February 16, 2012 (Enbridge, 2012a), and
- November 2013 through and including March 2014 – Data Gap Assessment.

1.4 Reach 3 Location and Land Use

Reach 3 is located less than 0.5 miles southwest of Marshall, Michigan (*Figure 1*). The geographic scope of Reach 3 includes slightly more than 0.5 miles of Talmadge Creek downstream of Division Drive, (MP 0.50) and ending at I-69 (MP 1.25). Reach 3 is composed of all or portions of seven parcels, which are listed below, along with their land use as defined on the City of Marshall Zoning Map dated December 8, 2009.

TC-B-017: 16235 Division Dr.

- Tax ID: 13-16-350-030-01
- Zoning/Land Use: Agricultural/Agricultural and Residential

TC-B-019: 16195 Division Dr.

- Tax ID: 13-16-350-030-03
- Zoning/Land Use: Agricultural/Residential

TC-B-021; Division Dr.

- Tax ID: 13-16-350-030-05
- Zoning/Land Use: Agricultural/Undeveloped

TC-B-023: 12224 16 Mile Rd

- Tax ID: 13-16-341-051-03.
- Zoning/Land Use: Agricultural/Undeveloped

TC-B-024: 12374 16 Mile Rd

- Tax ID: 13-16-341-051-01
- Zoning/Land Use: Agricultural/Residential

TC-B-024.001: 12400 16 Mile Rd

- Tax ID: 13-16-341-051-06
- Zoning/Land Use: Agricultural/Residential

TC-B-025: 16 Mile Rd

- Tax ID: 13-16-350-030-06
- Zoning/Land Use: Agricultural/Residential

The boundaries of the Reach 3 Spill Area, along with the parcel boundaries for the seven properties that compose Reach 3, are depicted on *Figure 1*. *Figure 1* was created from the existing legal descriptions of the individual parcels. The legal descriptions were obtained from the Calhoun County Clerk's office and the zoning information was obtained from Marshall Township. Legal descriptions are summarized in *Attachment A*.

All seven parcels that comprise the Reach 3 Spill Area were purchased by Tri-State Holdings, LLC in 2010 and 2011. Single-family homes are present on five of the parcels within Reach 3 and these homes were occupied in 2010 when the Line 6B crude oil release occurred. These five residentially developed properties each have one potable well that was included in the residential well sampling program. There are five potable wells on the parcels that comprise Reach 3; however, only one potable well (C002471A) is located within the Reach 3 Spill Area boundary.

1.5 General Hydrology and Geology of Talmadge Creek and Kalamazoo River Valley

Quaternary geology of the Kalamazoo River watershed is mapped as glacial outwash sand and gravel and postglacial alluvium (Wesley, 2005). The glacial deposits include channel deposits, outwash, and till. Alluvium and glacial-stream deposits that are interconnected are referred to as channel deposits. Sand and gravel outwash is abundant and interspersed throughout the watershed. The predominant glacial feature of the area is the Tekonsha Moraine, which extends generally parallel to the Kalamazoo River from Morrow Lake to the east. The Tekonsha Moraine consists of primarily sandy till that also contains thin clay layers and discontinuous areas of sand and gravel.

Glacial geology within the Kalamazoo River basin is described as complex, and lithostratigraphic correlation can be difficult due to lateral and vertical heterogeneity of glacial deposits with a complex depositional history. Modern alluvial sediments present along the

river further add complexity and can be difficult to differentiate from glacio-fluvial outwash (Apple and Reeves, 2007). These glacial deposits affect groundwater movement and the behavior of streams and rivers. The Kalamazoo River basin, which is dominated by well-drained outwash, coarse end-moraine deposits, and ice contact deposits, has higher groundwater yields compared to basins with less permeable deposits (Bent, 1971). Outwash is the predominant depositional material in the basin, and contributes to moderately high groundwater deliveries to the river system (Wesley, 2005).

The primary bedrock units are Mississippian in age and include the Marshall Sandstone throughout the Kalamazoo River basin in Calhoun County and the Coldwater Shale in portions of Kalamazoo County (WMU, 1981). Due to differential erosion, the depth to bedrock varies within the investigative area from ground surface to approximately 200 feet (ft) below ground surface (bgs). Bedrock was not encountered within Reach 3.

The Marshall Sandstone consists of the Upper Marshall or Napoleon Sandstone member and the Lower Marshall Sandstone. The upper member is recognizable only in exposures in the southern part of the Michigan basin, which includes Reach 3. The Napoleon Sandstone is locally considered an unconfined aquifer (Apple and Reeves, 2007).

The upper surface of the Marshall Sandstone is an erosional contact, which is typically weathered, friable, fractured, and surficially irregular. The Marshall Sandstone is predominately a fine to coarse-grained sandstone with interbeds of siltstone, sandy shale, and shale. In general, grain size decreases with depth and the Marshall Sandstone is sparsely fossiliferous, sometimes cross-bedded and rippled, very fine- to coarse-grained sandstone of buff, tan, or gray color. Interbeds of siltstone, sandy shale and shale, are also present at depth (Harrell, et al., 1991).

The main soils types within the Kalamazoo River basin are loam, sand, and muck (Rachol et al., 2005). Within the overall area, the predominant general surficial soil types are sandy loam, fine sand, and sandy clay loam. Based on historical field observations, Reach 3 soils along Talmadge Creek consisted of surficial organic soils averaging 3 ft in thickness, underlain by silt, clay, and sand. A series of geologic cross sections were constructed during 2010 for the first 1.25 miles of Talmadge Creek (from MP 0.00 – MP 1.25), which includes all of Reach 3 (MP 0.50 to I-69), as shown on *Figure 2*. The soil units are not contiguous across the entire Reach, but tend to overlap each other as shown in the cross sections.

In these well-drained soils, a large amount of precipitation and snowmelt percolates to the groundwater and the groundwater flows to the associated tributaries such as Talmadge Creek and sub-basin wetlands (Wesley, 2005).

Given the location of Reach 3, regional vertical gradients are likely upward into the stream. However, within the shallow, unconsolidated soil deposits, horizontal gradients will dominate with groundwater flow generally parallel to Talmadge Creek. Groundwater flow will be faster in more granular, more permeable deposits and slower in the fine grained, less permeable deposits.

Based on the borings completed within the Reach 3 Spill Area, the geology along Talmadge Creek between MP 0.50 and MP 0.75 consists of organic soils from 1 ft to 6 ft thick, overlying sands from 3 ft to 12 ft thick or silt materials from 2 ft to 7 ft thick. Interbedded gravel and silt layers were encountered at some locations within the sand layer. A clay layer from 1 ft to 2 ft thick was also encountered between the organic soil and silt or sand layers in some locations. Bedrock was not encountered during drilling operations along Talmadge Creek between MP 0.50 - MP 0.75.

The geology along Talmadge Creek between MP 0.75 and the wetland area near MP 1.00 consists primarily of organic soils from 2 ft to 8 ft overlying sands and/or silt materials from 1 ft to 7 ft thick. The organic soils are interbedded with sand, peat, silt, and clay layers. At one location, a clay layer approximately 8 ft thick was encountered beneath 1 ft of organic soil. Bedrock was not encountered during drilling operations along Talmadge Creek between MP 0.75 and the wetland area.

The geology along Talmadge Creek between the wetland area and beyond MP 1.00 to I-69 consists of a shallow layer of organic soil from less than 1 ft to 2 ft thick overlying silt or clay materials 1 ft to 5 ft thick followed by a sand/gravel layer from 2 ft to 5 ft thick. At two locations, a second organic soil layer from 1 ft to 3 ft thick was encountered between the silt/clay and sand/gravel layers. At two other locations, a clay layer approximately 1 ft thick is present at the surface or beneath a thin layer of organic soil. Additionally, gravel/sand layers were present at the surface overlying a layer of silt or organic soil at two locations. Bedrock was not encountered during drilling operations along Talmadge Creek between the wetland area and I-69. Geologic cross sections of the Reach 3 Spill Area are presented on *Figure 2*.

The groundwater at Talmadge Creek was observed at depths ranging from 0.0 ft to 9.2 ft bgs. During Source Area activities, groundwater flow was documented to flow locally into Talmadge Creek with a regional flow west towards the Kalamazoo River. The flow volume of Talmadge Creek increases as it approaches the river, as noted by observing Talmadge Creek where it crosses under 17 Mile Road south of Marshall, Michigan (less than 4 ft wide) compared to where it enters the Kalamazoo River (more than 6 ft wide). In addition, groundwater flow was observed to flow into the Kalamazoo River during the *Evaluation of Potential Impact of Released Oil on Groundwater used for Drinking Water (Hydrogeologic Evaluation Report),* submitted to the U.S. EPA on October 30, 2010 (Enbridge, 2010c). Based on the above observations, it was determined that Talmadge Creek is a gaining stream and groundwater flows into the creek from the surrounding areas.

Groundwater is used as a source of drinking water in the rural areas along Talmadge Creek and the Kalamazoo River. Naturally occurring metals are locally present in the groundwater. In addition, known sites of environmental impact were present prior to the Line 6B crude oil release along the Kalamazoo River, which have resulted in locally impacted soil and groundwater.

Enbridge has undertaken an extensive potable well monitoring program that verifies the absence of impact based upon the evaluation of more than 2,000 potable water samples collected from private wells along Talmadge Creek and the Kalamazoo River. *Figure 3* depicts the locations of potable wells located along Reach 3.

1.6 Line 6B Crude Oil Composition

The Line 6B crude oil release occurred at a time when Line 6B was transitioning from a batch of Western Canadian Select (WCS) to a batch of Cold Lake Blend (CL). As a result, the crude oil that was released was a blend of these two components.

The WCS component is a blend of Canadian heavy conventional and bitumen crude oils combined with sweet synthetic and condensate diluents (added to improve flow characteristics). The CL component is a heavy crude blend of bitumen and condensate. The compositional analysis of the Line 6B crude oil is detailed in the *White Paper: Evaluation of Line 6B Crude Oil PNA and VOC Related Risk to Groundwater Quality,* submitted to the MDEQ on July 24, 2014 (Enbridge, 2014b).

Since its release, the Line 6B crude oil has undergone chemical and physical changes referred to as “weathering”. As the crude oil interacted with water and air in the environment, lighter diluents were lost to volatilization and the composition of the remaining Line 6B crude oil became less volatile . To quantify the chemical composition of fresh and weathered Line 6B crude oil, three relatively fresh, unweathered crude oil samples (two upstream pipeline samples and one Line 6B crude oil release sample) and one weathered sample (collected approximately 13 miles downstream of the release site, approximately 1.5 years after the release) were submitted for laboratory analyses. The analytical results show that the weathered sample has comparatively less C_9 to C_{37} hydrocarbons, polynuclear aromatic hydrocarbons (PNAs), total petroleum hydrocarbons (TPH), and volatile fractions than the fresh, unweathered samples.

Volatile organic compounds (VOCs) detected in the crude oil analysis were presented in the defined analyte list in the approved *Quality Assurance Project Plan (QAPP),* submitted to the MDEQ on August 19, 2011 (QAPP) (Enbridge, 2011d). The QAPP defined VOC analyte list includes: benzene, toluene, ethylbenzene, xylenes, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, isopropylbenzene, n-propylbenzene, n-butylbenzene, sec-butylbenzene, 4-isopropyltoluene, and cyclohexane. Two additional VOC compounds in the QAPP defined analyte list, but not included in *Table 1.1e* of the *Analytical Quality Assurance Plan*, submitted to the U.S. EPA on December 21, 2012 (Enbridge, 2012b) which governed the crude oil analyses, are 1,2,3-trimethylbenzene and tert-butylbenzene. This group of 14 VOCs is collectively hereafter, referred to as petroleum VOCs (PVOCs).

PVOC concentrations in the Line 6B crude oil samples vary from 40 milligrams per kilogram (mg/kg) to 4,000 mg/kg (between 0.004% and 0.4%) and therefore are not major components of the oil. PVOCs are rapidly lost during weathering. This is reflected in the infrequent detection of these compounds (less than 6% of samples collected). Weathering of the Line 6B crude oil typically reduced the PVOC concentrations to levels below the laboratory reporting limits (RLs).

PNAs are chemicals that consist of two or more fused benzene rings, and are also present in crude oil. PNAs are less volatile than PVOCs. A subset of these PNAs (16 non-alkylated PNAs, referred to as “parent” PNAs) is included on the U.S. EPA Priority Pollutant list of PNAs. Alkylated PNAs have a straight carbon chain (such as a methyl or ethyl group) attached to a benzene ring. Parent PNAs are minor components (non-detect to <100 parts

per million (ppm)) of petroleum such as the Line 6B crude oil. This is significant when evaluating for the presence and implications of a specific oil release. It is important to have an understanding of the broad spectrum of PNAs potentially present in the environment and their likely origins, which can be pyrogenic or petrogenic.

Pyrogenic PNAs are formed by the rapid, high temperature combustion of motor, bunker, and power plant (coals and petroleum) fuels. Pyrogenic PNAs are also formed in the processing of coals into coal tars and coal tar products (i.e., creosote or coal tar pitch used in aluminum smelters). These pyrogenic PNAs are commonly associated with manufactured gas plant operations, coal burning, as well as internal combustion engine exhaust. Petrogenic PNAs are formed through slow, long-term, moderate temperature processes, and are associated with fossil fuels (petroleum and coal). Petrogenic PNAs are those associated with fossil fuels that have not undergone combustion.

Pyrogenic and petrogenic PNAs are readily distinguishable based on their alkylated PNA distribution. Petrogenic PNAs have a relative abundance of alkylated PNAs relative to the parent PNAs and as a result, the pattern of PNAs (“fingerprint”) can be used to ascertain the source of PNAs in a given environmental sample. Analyses have shown that the Line 6B crude oil blend produces a unique petrogenic PNA chemical signature in fresh and weathered states that can be distinguished from unrelated background pyrogenic PNAs present in the Kalamazoo River soil and sediment. These analyses were used to develop a unique “fingerprint” reference signature, that was presented in two reports to the MDEQ in 2013 (*Supplement to the Response Plan for Downstream Impacted Areas, commonly referred to as the "Quantification of Submerged Oil Report*", submitted to the MDEQ on March 21, 2013 (Enbridge, 2013b), and the *Report of Findings for Hydrocarbon Fingerprint Evaluation in Overbank Soil,* submitted to the MDEQ on May 7, 2013 (Enbridge, 2013c)).

Chemical analysis of weathered and unweathered Line 6B crude oil will be further detailed in the *White Paper: Urban PAH Background Evaluation*, which is currently in development.

2.0 Project Background

This section of the RI Report presents an overview of the various response actions, investigations, remedial actions, and reporting that was conducted to characterize the overbank portion of the Spill Area, and specifically the Reach 3 Spill Area overbank areas. Observations and results obtained from each aspect of work performed on this project were used to focus follow-up work in areas where it was required. The locations of all soil, sediment, groundwater, and surface water samples collected are presented on *Figure 4*. The approach of using observations and results from one effort to guide subsequent efforts has been a hallmark of this project. It has enabled Enbridge to focus efforts to characterize, remediate, stabilize, and verify conditions at the Reach 3 Spill Area.

Enbridge identified a release of crude oil from its Line 6B pipeline on July 26, 2010. The Line 6B crude oil flowed down Talmadge Creek to the confluence with the Kalamazoo River, and into the Kalamazoo River. Immediately following the Line 6B crude oil release, Enbridge performed a variety of initial response actions to contain and capture the majority of the Line 6B crude oil that was released. These activities were conducted in the Source Area, on Talmadge Creek, and on the Kalamazoo River.

In conjunction with the initial response actions, the SCAT process was implemented to first identify and categorize the observed impacts and then recommend a remedial action. Following initial cleanup, the location and extent of any remaining oiled areas were documented and cataloged using the SCAT Reassessment Operations and Maintenance Form. This catalog became known as the Operations and Maintenance (O&M) activities list or O&M Sites. The sites requiring additional cleanup were transferred to the O&M program in late 2010 for continued remedial actions and/or more in depth evaluations. The O&M program was designed to employ the cleanup techniques used during SCAT on a regular basis while monitoring and documenting the progress. Then in early 2011, under the direction of U.S. EPA, SORT was conducted to locate and categorize the visible occurrences of remaining Line 6B crude oil along the shoreline and overbank areas of Talmadge Creek and the Kalamazoo River. This inspection included visual observations of previously identified SCAT and O&M sites. Cleanup at many of these locations was completed throughout the summer of 2011.

To consolidate the data collected under the multiple programs (SCAT, SORT, and SOTF), it became necessary to compile all observations from outstanding locations into one program, to facilitate evaluation and categorization of the information. This program was known as Outstanding Sites Characterization and Reconciliation (OSCAR). Under the OSCAR program, all available data was evaluated and when necessary, additional visual assessments were conducted in conjunction with U.S. EPA, to determine a site's potential to produce sheen on the Kalamazoo River. As a result of the OSCAR program, the multiple data sources were restructured into three main categories: OOR, SOTF, and RI. With this restructuring and the O&M signoff process, the O&M program was discontinued. The water-inundated portions of the Spill Area were further investigated under the SOTF program, areas requiring surface cleanup were investigated under the OOR program, and the locations that satisfied the U.S. EPA cleanup objectives were transferred to MDEQ oversight for continuing remedial investigations.

While future remediation was planned for many of the OOR locations, some were located in ecologically sensitive "critical habitats" as defined by the MDEQ, and were therefore assigned to the High Priority OSCAR (HP OSCAR) list. The objective of creating the HP OSCAR list was to evaluate risk verses ecological sensitivity when proposing additional cleanup at these locations.

Following the OOR Program, the 2012 SORT reassessment employed a more targeted approach to reassess a subset of the locations (polygons and points) identified during the 2011 SORT. The completion of the 2012 SORT reassessment marked the last complete reassessment of the overbank prior to the initiation of the Kalamazoo River Remedial Investigation.

The TCRI was conducted on the Reach 3 portion of Talmadge Creek commencing in September 2011. The goal of the TCRI was to assess the effectiveness of the response actions that had been previously performed in the area, to define the nature and extent of remaining impacts from the release of Line 6B crude oil to the sediment and floodplain area, and to identify the necessity and extent of any future remediation activities.

The following sections provide a detailed description of the activities introduced above, and specify to what extent, if any, these activities were conducted within the Reach 3 Spill Area.

2.1 Initial Response Activity

During and after the Line 6B crude oil release, Enbridge performed response and interim restoration activities to address the impacts from the release. These activities included a rapid mobilization of personnel and equipment to initiate immediate removal of the Line 6B crude oil from the environment. Response and interim restoration activities in the Source Area, Talmadge Creek, and the Kalamazoo River included, but were not limited to the following:

- Shutdown of the pipeline and closures of pipeline isolation valves,
- Installation and operation of flumes (underflow weirs) down gradient of the release area,
- Installation and operation of Line 6B crude oil and water containment and recovery systems,
- Development and implementation of plans for remediation of the Source Area and downstream impacts,
- Excavation of impacted Source Area, Talmadge Creek, and downstream impacted areas,
- Development of a qualitative ecological characterization of Talmadge Creek and the Kalamazoo River,
- Sampling and analysis of private and public drinking water wells,
- Use of SCAT, and
- Implementation of SORT to identify oiled shoreline and floodplain areas, and recommend appropriate cleanup treatment methods.

2.2 Shoreline Cleanup and Assessment Technique Activities

During the initial response activities, the SCAT process was used to assess and address impacts associated with the release of crude oil from Line 6B. SCAT was a multi-step process that included an initial assessment of areas affected by the release and procedural cleanup recommendations based on the Cleanup Recommendation Methods that were developed by the Environmental Advisory Group. Cleanup activities depended on the location of the impact such as lawns, floodplains, and shorelines; and, included the following methods:

- Cut and bag low hanging limbs extending over and into the water, 2 inches above oiling level,
- Remove oiled vegetation leaving roots intact, up to 10 ft from the waterline,

- Remove pooled oil using portable vacuum or absorption techniques (e.g., snare/pom-poms, sorbent pads, etc.),
- Manually remove oil and contaminated soil where persistent oil occurs in 'moderate' to 'heavy' amounts, by removing with flat shovels, rags, sorbent pads, gentle raking, gloved hands, hand tools, or similar manual methods, and
- Eliminate layers of solid oil and tar using manual methods that may include gentle raking, removal by hand (with appropriate personal protective equipment), and hand tools.

SCAT activities were limited to the Kalamazoo River and associated shoreline and floodplain areas. SCAT was not performed on Talmadge Creek where multiple excavations were employed to remove the Line 6B crude oil residuals. Evaluations performed through the SCAT process documented the conditions along the river. Several independent inspection teams (composed of Enbridge, U.S. EPA, and MDEQ personnel) followed the SCAT cleanup teams to reassess each segment and confirm that the initial cleanup was completed in accordance with the initial recommendations.

During the SCAT reassessment phase, the SCAT teams identified areas that could not be fully remediated using the Cleanup Recommendation Methods. The location and extent of these remaining oiled areas were documented using the Operations Cleanup Recommendations Form with the intent of cataloging those areas that required additional remediation and/or monitoring following the completion of the SCAT process. This catalog became known as the O&M activities list or O&M Sites. None of the O&M Sites were present within the Reach 3 Spill Area. Locations where remaining Line 6B crude oil occurrences had been identified were addressed under the OSCAR program, which consisted of a series of shallow observational borings during which subsurface conditions were characterized. None of the OSCAR investigation areas were located in the Reach 3 Spill Area.

2.3 Submerged Oil Task Force Activities

The SOTF investigation conducted in the fall of 2010 quantitatively assessed submerged oil within the in-channel portions of Talmadge Creek and the Kalamazoo River. The SOTF was composed of representatives from the U.S. EPA, MDEQ, stakeholders, and Enbridge and their contractors. These efforts included characterization and mapping of submerged oil impacts along Talmadge Creek, Kalamazoo River, and Morrow Lake. Several sediment

samples were collected within Reach 3 under the SOTF. A discussion of the SOTF sampling results is included in the sediment sampling results discussed in *Section 4.3.2.*

2.4 Shoreline and Overbank Re-assessment Technique

SORT was the assessment technique used by Enbridge, MDEQ, and U.S. EPA to characterize the observed visible Line 6B crude oil impacts on the overbank portions of Talmadge Creek and the Kalamazoo River. SORT was conducted on both Talmadge Creek and the Kalamazoo River in the spring of 2011 and again on the Kalamazoo River in 2012. The SORT activities were conducted in response to the requirements of the Notice to Enbridge dated March 7, 2011 (U.S. EPA, 2011). The Notice directed Enbridge to perform assessment activities pursuant to the U.S. EPA Order and the Supplemental Order.

The SORT that was developed for the assessment of Line 6B crude oil impacts was based on techniques from the SCAT survey system used in the National Oceanic and Atmospheric Administration (NOAA) *Shoreline Assessment Manual* (NOAA, 2000), which is used for the rapid assessment of shoreline habitats in a marine setting. However, in this case, these techniques were modified for use in a riverine environment. SORT surveys were conducted by boat and/or on foot, on targeted shoreline and accessible overbank areas. The surveys evaluated the overbank conditions, and assessed and documented the presence of visible Line 6B crude oil impacts.

The 2011 SORT emphasized a comprehensive assessment of the entire flood plain, which was inundated by water during the Line 6B crude oil release. SORT field teams included representatives from Enbridge, MDEQ, and U.S. EPA. At specific locations, where the teams did not have a consensus regarding visual evidence of surficial oil impact, a conservative “when in doubt, map it out” approach was used to resolve any conflicts of opinion that occurred. The objective of this assessment was to identify the presence of visible remaining Line 6B crude oil along the shoreline and overbank area from Talmadge Creek (starting at MP 0.00) to the dam at Morrow Lake (ending at MP 40.00) on the Kalamazoo River.

The following SORT procedures were performed:

- Identified and estimated the areas (labeled numerically so as not to conflict with initial SCAT efforts in 2010) of specific oiling and substrate conditions present,
- Ground truthed the United States Geological Survey (USGS) inundation model within each 0.25-mile segment of Kalamazoo River,

- Characterized oiling conditions and substrate types using a standardized terminology,
- Characterized shoreline and overbank habitat types and the degree and characteristics of any oiling conditions present,
- Recorded percent cover of specific oiling conditions within a point/zone on field maps and data collection forms, and
- Collected a waypoint and/or polygon outline, using a global positioning system (GPS) unit with sub-meter accuracy, for each of the oiled points/zones identified as potentially requiring additional response activities.

As stated in the approved *Sampling and Analysis Plan (SAP)*, submitted to the MDEQ on August 30, 2011 (SAP) (Enbridge, 2011e), SORT observations were captured on field forms using Trimble Yuma® digital tablets in accordance with the Standard Operating Procedures (SOPs), *SOP EN -104, Survey* and *SOP EN-101, Field Records* as stated in the SAP and provided in *Attachment B*. The field form contained a signatory area for the U.S. EPA's Superfund Technical Assessment and Response Team (START) representative, MDEQ representative, and an Enbridge representative, to verify that the data collected on the sheet was accurate.

The observations were compiled into SORT sign-off sheets, which were reviewed and subsequently approved by the U.S. EPA, START, MDEQ, and Enbridge personnel. The individual SORT sign-off sheets for each segment in Reach 3 Spill Area contain signatures from these parties, which indicate that the segment was adequately assessed and documented.

While the 2011 SORT was an assessment of the entire floodplain that was inundated by water at the time of the July 2010 Line 6B crude oil release, the 2012 SORT assessment focused on areas that had been recommended for additional remedial efforts by the 2011 SORT. During the time between the two SORT events, Enbridge and the U.S. EPA continued to conduct removal actions. The areas of the Reach 3 Spill Area that were recommended for additional work during the spring of 2011 SORT were excavated during the winter of 2011; therefore, the 2012 SORT reassessment was not performed in the Reach 3 Spill Area.

The results of the 2011 Reach 3 SORT activities are summarized in *Section 4.2*. Locations of 2011 SORT features are included on *Figure 5.* The 2011 SORT reports and sign-off sheets,

and the SORT guideline containing descriptions for habitat, oil distribution, and oil type and thickness are presented in *Attachment C*.

2.5 Remedial Actions

Excavations have been conducted in the Reach 3 Spill Area of Talmadge Creek since the Line 6B crude oil release. Emergency response activities performed during the fall of 2010 included excavation of visually impacted soils from areas adjacent to Talmadge Creek. During the winter of 2011, impacted Reach 3 Spill Area soil and sediment that had previously been identified during work conducted in 2010 and 2011 were excavated. This excavation included streambed sediments, several selected overbank areas, and portions of the adjacent wetland (including removal of impacted vegetation); and replacing coir logs that were installed in 2010. These remedial excavations are discussed in detail in *Section 4* of this document.

2.6 Talmadge Creek Remedial Investigation

An RI was conducted on the Reach 3 Spill Area portion of Talmadge Creek commencing in September 2011. The TCRI was conducted in accordance with the approved RIWP. The goal of the TCRI was to assess the effectiveness of the response actions that had previously been performed in the area, to define the nature and extent of remaining impacts from the release of Line 6B crude oil to the sediment and floodplain area, and to identify the necessity and extent of any future remediation activities. The RI conducted along Talmadge Creek included sampling of soil, sediment, groundwater, and surface water; visual observation for Line 6B crude oil sheen; and, screening for Line 6B crude oil in the soil matrix using ultraviolet (UV) fluorescence. The Reach 3 Spill Area falls within this section of Talmadge Creek, and is defined as MP 0.50 through the first portion of MP 1.25, ending at I-69. The investigation was structured with an “outside in” approach. Initial borings were placed beyond the extent of impact and subsequent borings were placed closer to the creek, to identify the boundary of Line 6B crude oil impact. Results from this effort were used to guide the subsequent excavation.

The data presented in this report includes samples collected within the Reach 3 Spill Area, between MP 0.50 - MP 1.25. Due to the geology and hydrogeology of the Line 6B crude oil impacted area along Talmadge Creek, many of the soil samples were collected below the water table (saturated soil samples), as agreed upon by Enbridge and the MDEQ. To supplement the saturated soil analytical results, groundwater samples were collected from temporary wells using low flow sampling techniques, in accordance with the *SOP EN-406,*

Groundwater Sampling via Temporary Well as stated in the SAP and *SOP EN-406, Addendum to Groundwater Sampling via Temporary Well*, both presented in *Attachment B*.

2.7 Potable Wells

Enbridge has undertaken an extensive potable well monitoring program. The objective of this program is to monitor groundwater quality in residential wells and community water supply wells to evaluate potential risk to public health. The monitoring program has verified the absence of Line 6B crude oil impact in all the sampled wells throughout the entire Spill Area.

One potable water well (C002471A) is located within Reach 3 Spill Area and an additional four potable water wells are located within Reach 3, but are outside the Spill Area boundary. These wells have been sampled periodically as part of the approved *SAP Attachment B Drinking Water Well Supplement to the Sampling and Analysis Plan,* submitted to the MDEQ on April 10, 2013 (Enbridge, 2013d). Sample frequency has been variable, but was generally more frequent (monthly to quarterly) immediately following the Line 6B crude oil release and less frequent since 2012 (semi-annual to annual). Potable well sampling was performed in accordance with *SOP EN-405, Sample Collection from Drinking Water Wells*, as stated in the SAP and presented in *Attachment B*. Potable well impacts have not been detected in Reach 3 and the vertical extent of groundwater being evaluated for potential impact is much shallower (the upper 10 ft) than the potable well screens. Further, the shallow (near surface) groundwater flow system within Reach 3 will act to preclude deep groundwater impacts. The shallow groundwater generally flows towards or parallel to Talmadge Creek and the Kalamazoo River, ultimately with discharge into the creek and/or river. These flow directions are consistent with the CSM-2014. *Figure 3* depicts the location of potable wells. *Table 1* presents a tabulated summary of the analytical data collected from these potable wells.

3.0 Investigative Methods

This section discusses the investigative methods used in the Reach 3 characterization and also discusses several aspects of the analytical program. Reach 3 was the subject of multiple investigations, which incorporated multiple investigation methods including: SCAT, LIF, SORT, FLS, PI, high resolution UV photography/logging, high resolution aerial photography, TCRI, auxiliary area assessments, and quarterly groundwater monitoring. The work was conducted in accordance with approved work plans, where applicable. Where warranted, additional studies have been undertaken to evaluate issues of commonly occurring analytes (metals) and elevated reporting limits (ERLs) resulting from analyzing soil samples with high moisture content. The site characterization was conducted on the Reach 3 portion of Talmadge Creek commencing in September 2011, in accordance with the following approved work plans:

- QAPP,
- SAP,
- RIWP,
- Approved *Talmadge Creek Remedial Investigation Work Plan MP 0.50 – 2.25, Supplement: Additional Investigation of Impacted Areas,* submitted to the MDEQ on December 28, 2011 (RIWP Supplement), (Enbridge, 2011f), and
- *Post-Response Shallow Soil Assessment Work Plan,* submitted to the U.S. EPA on September 4, 2010 (Enbridge, 2010d).

During the execution of these work plans as well as during post excavation sampling efforts, Enbridge routinely used observations, screening results, and analytical results to direct and focus subsequent sampling and characterization efforts. This approach of using prior results to focus sampling toward locations with known or suspected impact was used throughout the efforts to characterize, remediate, and verify conditions within the Reach 3 Spill Area. Great effort was expended to select sample locations with the highest likelihood of Line 6B crude oil impacts. MDEQ provided oversight of field operations and routine meetings were conducted to discuss investigation results and strategies. The following efforts were used to select sample locations that would reflect worst-case scenario conditions:

- Use of GPS to direct field crew to previously identified SCAT/SORT polygons within the investigation area,

- Inspection of each polygon to determine a location within the polygon that was most likely to have residual impacts (i.e., depressions in the ground surface that could have caused a pooling of Line 6B crude oil),
- Collection of soil/sediment core for UV logging/photography and logging of composition (implemented in mid-2011),
- Use of UV results to select the soil sample collection interval within a soil core with the greatest likelihood of impact for subsequent laboratory analysis,
- Use of soil UV results and/or soil analytical results to determine the most appropriate location for the installation of a temporary well (location of most likely impact, if impact were present), and
- Use of soil UV results and/or soil analytical results to determine the most appropriate interval within a temporary well for representative groundwater sampling.

It should be noted that the sample selection strategy for a particular investigation step depended on the objectives of the work plan under which the work was conducted. As an example, during the 2011 TCRI, the soil and groundwater sampling strategy focused on delineating non-impacted areas. As a result, laboratory analysis was typically conducted on samples that showed little if any visual or UV impacts.

The following sections describe the investigation methods used on Talmadge Creek in 2011, 2012, 2013, and 2014; and, the auxiliary sites in 2011.

3.1 Soil Borings and Sample Characterization

This section describes the methods used to advance soil borings in the Reach 3 Spill Area as well as the techniques used to log soil samples. Soil borings were advanced manually and using direct-push drill rigs. All soil boring logs, visible light photographs, and relative UV photographs are included in *Attachment D* and are divided into sections correlating to the area and the date of boring installation.

3.1.1 Manual Borings

Soil cores were collected manually throughout the Reach 3 Spill Area in locations inaccessible to drill rigs and to expedite the collection of soil samples. This method of collecting soil cores was selected based on the soft, organic and generally easily penetrated nature of soil present, and the existence of shallow groundwater for easy temporary well installation. In addition, the most likely location for crude oil impact to be observed was the near surface soil. Collection of

cores involved the use of a check valve sampler for shallow borings, a manual Geoprobe® coring tool for deeper borings, or a combination of both techniques in accordance with the *SOP EN-305, Soil Sampling via Hand Auger* and *SOP EN-301, Subsurface Soil Sampling by Geoprobe® Methods*, both as stated in the SAP and presented in *Attachment B*.

The check valve sampler consisted of a 2.75-inch diameter, 4 to 5-foot long clear plastic liner (polyethylene terephthalate glycol or polyvinyl chloride (PVC)) or polycarbonate liner with a check valve on the head of the tube. The sampler was manually pushed into the surface soil or soft sediment until resistance was encountered. The manual Geoprobe® coring tool consisted of a 2-inch diameter polycarbonate tube that was inserted into a stainless-steel Macro-core® sample tube with stainless-steel cutting shoe and drive head. The Geoprobe® tool had a stainless steel drive rod with drive cap extending from the top and a sliding drive hammer was placed over the drive rod. The hammer was then used to advance the tool into the soil to the desired depth. New polycarbonate tubes were used for each coring attempt.

All equipment that came in contact with the soil was decontaminated prior to use and between boring locations, in accordance with *SOP EN-105, Decontamination of Field Equipment* as stated in the SAP and presented in *Attachment B*.

3.1.2 Direct Push Drilling

Where access permitted, and deeper soil samples were required, borings were advanced using direct-push (Geoprobe®) drilling method. In these borings, soil cores were collected using a Macro-Core® sampling barrel or similar continuous soil sampling methods in accordance with *SOP EN-301, Subsurface Soil Sampling by GeoProbe® Method,* as stated in the SAP and presented in *Attachment B.*

3.1.3 Soil Core/Sample Characterization

Soils were logged using the Unified Soil Classification System (USCS) (ASTM, 1985) and in accordance with *SOP EN-101, Field Records*, as stated in the SAP and presented in *Attachment B.* Soil cores were logged to evaluate the presence of potential Line 6B crude oil using UV fluorescence and visible light, as well as to document subsurface stratigraphy and soil characteristics (e.g., structure, color, moisture, etc.). This evaluation included both visible and UV light photography. The use of UV and high-resolution photography as a screening tool was adapted and enhanced from similar procedures used in oil exploration but very rarely

employed in Michigan for environmental investigations. The refinement and enhancment of the equipment and procedure has been critical in accomplishing the goals of this project.

Aromatic petroleum hydrocarbons (i.e., alkyl-substituted aromatic hydrocarbons and aromatic amines) absorb light energy at a given wavelength and re-emit it in the form of fluorescence when exposed to UV light. This characteristic has been effective in identifying Line 6B crude oil residuals with a high degree of resolution. Therefore, UV fluorescence has been used as a screening tool for identifying the presence or absence of Line 6B crude oil in soil cores. Soil boring locations containing UV fluorescence were identified as areas of potential further investigation. Intervals within the soil cores with UV fluorescence were evaluated for the intensity and color of the florescence. Those intervals with maximum UV intensity were generally selected for sampling and analyses, similar to selecting intervals based on photoionization detector (PID) readings.

Prior to logging, the core was cut in half lengthwise and was screened with a UV light in a dark room. UV fluorescence observations were recorded on boring logs. Observations included the distribution, thickness, and approximate amount of UV fluoresced Line 6B crude oil (in percent coverage) as well as the physical appearance of any residual Line 6B crude oil (i.e., sheen, globules, and visible Line 6B crude oil) under normal light.

Subsurface stratigraphy and soil characteristics were described utilizing the Munsell Color System (Munsell, 2009), the USCS, and the *Field Guide for Soil and Stratigraphic Analysis v.2* (Field Guide) (Midwest Geosciences Group, 2006). For consistency, soil descriptions used the following format (adapted from the Field Guide):

- Munsell color (Munsell number),
- USCS classification,
- Moisture,
- Plasticity,
- Cohesiveness,
- Sedimentary structure,
- Secondary grain size and component information, and
- Other observations.

The soil saturation level was established in each borehole by reviewing the physical appearance of moisture conditions of the soil samples, the cores, and the borehole. Soil

samples collected from the cores were classified as unsaturated if the sample was collected above the apparent water table. Soil samples were classified as saturated if they contained free moisture (water) or if they were collected from below the saturated soil depth established for the borehole, based on field observations.

3.2 Temporary Well Installation and Sampling

This section describes temporary well installation as well as methods for water level measurement and representative groundwater sample collection.

3.2.1 Temporary Well Construction and Installation

To allow for the collection of strategically targeted groundwater samples, hand augers were used to install temporary wells. These wells were constructed of 1-inch diameter, schedule 40 PVC well casings with 10-slot (0.010-inch) PVC well screens. Screen lengths ranged from 1 ft to 3.5 ft, and the screened interval was positioned to target the area of interest in the soil boring. In most cases, a 3.5 ft screen was placed to intersect the top of the water table. On occasion, when UV fluorescence or other observations were identified below the water table, a shorter, 1-foot long screen was positioned to straddle the identified area of interest. By using smaller diameter casings and shorter well screen lengths in the temporary wells, the groundwater samples collected were more representative of conditions in the soil interval of interest. The temporary wells were installed utilizing manual equipment techniques in accordance with *SOP EN-406, Groundwater Sampling via Temporary Wells* as stated in the SAP, *SOP EN-406, Addendum to Groundwater Sampling via Temporary Well* (both presented in *Attachment B*), and the RIWP. As field conditions dictated, annular space around the well screen was filled by the natural collapse of the native material, emplacement of filter sand, or filter sand emplaced above natural collapse. A bentonite chip seal extended from the top of the filter pack to the ground surface, when necessary, to ensure the sample was being collected from the screened target interval.

3.2.2 Temporary Well Sampling

As is typical for temporary wells, the wells were not developed, but were purged prior to sampling, which typically occurred within 24 hours to 48 hours of installation. Groundwater samples were collected from the temporary wells using low flow sampling techniques, in accordance with *SOP EN-404, Low Flow Groundwater Sampling* as stated in the SAP and presented in *Attachment B*. Prior to sampling, efforts were made to achieve a turbidity of less than 10 nephelometric turbidity units. Groundwater samples collected for metals analyses

were unfiltered and were submitted for total metals analyses. Groundwater sampling forms used to record data that included groundwater pumping rates and water quality parameters are presented in *Attachment E*. These groundwater sampling forms also included information regarding groundwater depth, well screen length, well screen placement, and sampling depth. Immediately following the collection of groundwater samples, the temporary well casings and screens were removed and the boreholes were backfilled to the ground surface using bentonite pellets in accordance with the RIWP.

3.3 Cleanup Criteria and Screening Levels

Under the MDEQ Order, all assessment and remediation activities have been conducted pursuant to pertinent rules and regulations included in Part 201 of Michigan's Act 451 of 1994, as amended (Part 201). This report evaluates both the human health and terrestrial risks related to the Line 6B crude oil release as detailed in the sections below.

3.3.1 Human Health

The human health regulatory Criteria used as points of comparison to evaluate analytical results for soil, sediment, groundwater, surface water (collectively referred to as environmental media), and potable water are the following:

- Part 201 Generic Residential Soil Direct Contact Criteria (DCC),
- Part 201 Generic Residential Soil Drinking Water Protection Criteria (DWPC),
- Part 201 Generic Residential Soil Groundwater Surface Water Interface Protection Criteria (for soil) (GSIPC),
- Part 201 Generic Residential Soil Volatilization to Indoor Air Inhalation Criteria (SVIAIC),
- Part 201 Generic Residential Soil Ambient Air Infinite Source Volatile Soil Inhalation Criteria (VSIC),
- Particulate Soil Inhalation Criteria (PSIC),
- Part 201 Generic Residential Drinking Water Criteria (DWC),
- Part 201 Generic Residential Groundwater Surface Water Interface Criteria (for groundwater) (GSIC), and
- Part 201 Generic Residential Groundwater Volatilization to Indoor Air Inhalation Criteria (GVIAIC).

More specifically, each media was compared to the Criteria as listed below:

- Unsaturated soil results were compared to the DCC, DWPC, GSIPC, SVIAIC, and PSIC,
- Saturated soil and sediment results were compared to the DCC for screening purposes only (as requested by the MDEQ),
- Groundwater results were compared to DWC, GSIC, and GVIAIC, and
- Surface water was compared to GSIC as well as the Michigan Rule 323.1057 - MDEQ Rule 57 Water Quality Standards for human cancer and non-cancer nondrinking water sources. This includes Rule 57 Final Acute Value, Rule 57 Human Cancer Value Nondrinking Water Source, and Rule 57 Human Non-cancer Value Nondrinking Water Source.

The specific Criteria values are presented in *Table 2* of Part 201 Generic Cleanup Criteria and Screening Levels/Part 213 Risk Based Screening Levels of the MDEQ guidance published as part of the *Remediation and Redevelopment Division Operational Memorandum No. 1, - Attachment 7: Part 201 Generic Soil Inhalation Criteria for Ambient Air and Part 213 Tier I Soil Inhalation Risk-Based Screening levels for ambient air* (MDEQ, 2007).

3.3.2 Terrestrial

The U.S. EPA Region 5 Ecological Screening Levels (R5 ESLs) (U.S. EPA, 2003) were used to screen saturated and unsaturated soils as well as overbank sediments analytical results to evaluate the potential for terrestrial ecological risks associated with Reach 3 soil. The R5 ESLs are not cleanup criteria. R5 ESLs are screening levels that identify the potential for terrestrial ecological risks and the possible need for additional evaluation. The terrestrial ecological evaluation is discussed in *Section 5.1.14.*

3.4 Analytical Program

This section discusses the laboratory analytical program. This includes the analytical parameters used for this project, the quality assurance/quality control (QA/QC) evaluation of the laboratory results, ERLs, and the MDEQ split sample program.

3.4.1 Analytical Parameters

Soil, sediment, groundwater, surface water, and potable water samples were analyzed for the following parameters:

- Soils: VOCs; PNAs; total metals- beryllium, molybdenum, nickel, and vanadium; percent moisture; and, percent solids.
- Sediments: VOCs; PNAs; total metals- beryllium, mercury, molybdenum, nickel, and vanadium; percent moisture; and, total organic carbon (TOC).
- Groundwater: VOCs; PNAs; and, total metals (i.e., unfiltered) - beryllium, molybdenum, nickel, vanadium.
- Surface water: VOCs; PNAs; total metals (i.e., unfiltered) - beryllium, molybdenum, nickel, and vanadium.
- Potable water: VOCs; PNAs; pesticides; polychlorinated biphenyls; total metals (i.e., unfiltered); TOC; total suspended solids; and, hardness.

Initially, samples were analyzed for TPH. In 2012, Enbridge and the MDEQ mutually agreed to eliminate TPH as an analyte to evaluate the presence of Line 6B crude oil when other lines of evidence (UV fluorescence, visual assessment of oil/sheen, PNA concentration) were determined to be better indicators of the presence of Line 6B crude oil.

During excavation activities in 2010, metals analyses of Reach 3 soil samples were limited to barium, iron, nickel, and vanadium.

The analytical results for soil, sediment, groundwater, surface water, and potable water were compared to Criteria. However, for saturated soil and sediment, comparison to these Criteria must be used with caution, as the algorithms used to develop the residential Criteria do not account for saturated soil conditions. For this reason, and as agreed upon with the MDEQ, the analytical results for sediment and saturated soil samples were only compared to DCC. Further, this comparison was for reference only.

3.4.2 QA/QC Evaluation

The data quality reviews and data review summary were conducted by data reviewers and the project chemist. Soil, groundwater, sediment, and surface water analyses were performed using standard U.S. EPA approved methods in accordance with the QAPP, the SAP, and relevant work plans developed for the project. These analyses included QA/QC samples, which were collected at specified frequencies. QA/QC samples included field duplicates, matrix spike and matrix spike duplicates (MS/MSDs), trip blanks (VOCs only), rinse blanks (only for non-dedicated sample equipment), and method blanks. The analytical results of the

field duplicate samples are presented adjacent to those of their parent samples, in the data tables presented in this report.

Samples, duplicates, and laboratory MS/MSDs were collected at the following frequencies, as directed by the QAPP and SAP.

Type of Sample	Primary Sample	Duplicate	MS/MSD
Soil	1,226	104 (8%)	120 (10%)
Sediment	44	2 (4.5%)	3 (7%)
Groundwater	161	15 (9%)	34 (21%)
Surface Water	4	1 (25%)	2 (50%)

Note that the total number of each type of QA/QC sample was calculated from the proposed total number of samples collected during a particular phase of investigation, in this case the TCRI for MP 0.50 – MP 2.25. The QA/QC sample quantities were not calculated for a particular reach within that stretch. Therefore, the number of QA/QC samples for the Reach 3 specific data may not reflect the quantities indicated in the QAPP and SAP, but the appropriate number of QA/QC samples was collected for the overall investigation.

The laboratory analytical data used in this RI Report have undergone review in accordance with *Section 1.4.2* and *Section 4.1.3* of the QAPP. Data validation qualifiers were not added to the data as part of this effort; however, it should be noted that any data qualified as “estimated” (J-flagged) during formal data validation would be regarded as usable. Any rejectable (R-flagged) results were excluded or itemized as part of the Level 1 Review. A data review summary and individual Level 1 data review memoranda, are included in *Attachment F* of this report. The data assessment indicates that Reach 3 Spill Area samples were collected and analyzed in accordance with the QAPP, SAP, and relevant work plans. Several common laboratory contaminants (methylene chloride and acetone for example), which are not associated with Line 6B crude oil, have been sporadically detected in samples from the Reach 3 Spill Area. These results are included in the laboratory data packages and the tables associated with this report. However, to maintain focus on the relevant issues within the report, they are not discussed in the text of this RI Report.

Overall, the data was found to be of sufficient quality to meet the data use objectives of the project with the possible exception of the isolated VOC results from seven samples, as described below.

The Laboratory Control Sample (LCS) and Laboratory Control Sample Duplicate (LCSD) serve to monitor of the overall performance of each step during the analytical process, including the sample preparation, in a lab matrix, free of interferences. The LCS and LCSD is spiked with a known quantity of each analyte. When LCSs are analyzed, all LCS percent recoveries (%R) should fall within the established control limits. A low LCS %R for a particular analyte may indicate quantitation problems for that analyte. If the LCS %R is < 20%, then the associated non-detect results may be unusable per U.S. EPA's National Functional Guidelines for Superfund Organic Data Review. As part the analytical process, all LCS and LCSD results were evaluated for %Rs. The percent recovery for dichlorodifluoromethane in the LCS associated with the VOC samples in ALS Laboratories report 1402157 was below 20% and therefore the non-detect results for this analyte in samples SBTC0100L510S020414S029, SBTC0100L510D020414S029, and SBTC0125L502S020414S007 may not be usable. There were no other sample results rejected based on LCS/LCSD %Rs for the reviewed dataset.

The MS/MSD sample analysis is designed to provide information about the effect of each sample matrix on the sample preparation procedures and the measurement methodology. The MS/MSDs are prepared by adding a known quantity of each analyte to a field sample. A low MS/MSD %R for a particular analyte may indicate that there is matrix interference and an analyte may be under reported. As part of the analytical process, all MS/MSD results were evaluated for %Rs. There were four sample results where the associated MS/MSD %Rs were <20%, therefore the non-detect results may be unusable for the following VOCs in these specific samples: chloroethane in SBTC0100L031S091711S003 (lab ID 1109566-19); trichlorofluoromethane in ESTC0125L200S013112S005 (lab ID 1202035-01); trans-1,4-dichloro-2-butene in EWTC0125R004S020212GX (lab ID 1202079-01); and, 1,2,3-trimethylbenzene in SSTC0125R06S011013SX (lab ID 1301340-19). In all cases, the LCS recoveries associated with these samples were acceptable.

The remaining analytical results are acceptable for making the conclusions and interpretations contained within this RI Report. The data presented are of the appropriate quality, quantity, and representativeness to support project decisions.

3.4.3 Elevated Reporting Limits

An ongoing challenge on this project has been the presence of ERLs in soil sample analytical results. The RL is the concentration in a sample that is equivalent to the concentration of the lowest calibration standard. The entire analytical system must give a recognizable signal and an acceptable calibration point at this concentration. ERLs do not indicate that the analytes in question are present, only that the absence of a constituent above the Criteria, cannot be unequivocally established in that sample.

With the exception of the compounds dibromochloropropane and ethylene dibromide, the analytical methods employed for this project have RLs that are normally below the Criteria. However, the RLs of compounds analyzed using U.S. EPA Method SW8260 are frequently elevated when elevated concentrations of volatile organics are present in the sample, requiring sample dilution for accurate quantitation and instrument protection. RLs can also be affected by the moisture content of the soil sample. During the course of this project, there have been many soil samples for which the RLs were elevated above the DWPC and GSIPC. The analytical results for VOCs in soil samples were especially susceptible to ERLs due to the effects of high moisture content in soil samples (resulting in low sample dry weight) and/or any required methanol dilution of the sample due to high concentrations of an analyte. Values for these two variables (dry weight and the dilution factor) are entered into the equation that is used to calculate the RL, and can result in a higher than normal RL value. At soil moisture contents above approximately 35%, the resulting low sample dry weight often elevates the RL above the target detection limit (TDL), thus resulting in an ERL. As expected, this is problematic for soil samples collected on this project, where the water table is very shallow, often on the order of 1 ft bgs. The decision to collect and analyze saturated soil samples was mutually agreed upon by Enbridge and the MDEQ, early on in the project. While aware of the limitations and issues that the analysis of such samples would create, the data was collected to provide information for the evaluation of the Line 6B crude oil release.

In all cases, the RLs were elevated above DWPC for dibromochloropropane (1-2, Dibromo-3-chloropropane, CAS No 96-12-8) and ethylene dibromide (1,2-dibromoethane, CAS no. 106-93-4). This is due to the fact that, in the project QAPP the RLs for these compounds were specified based on the standard RL achievable using U.S. EPA Method 8260, which is the analytical method that was used. However, the agreed upon standard U.S. EPA Method 8260 RLs for these compounds, in both soil and water, are above the lowest DWPC and the TDL. Consequently, these compounds will always have an

elevated RL. These ERLs are an artifact of the standard RL for the analytical method used, which was agreed to by the MDEQ at the time the QAPP was developed.

In the context of this project, ERLs in groundwater samples are limited to the two VOCs: ethylene dibromide and dibromochloropropane. As stated previously, these ERLs are an artifact of the use of U.S. EPA Method 8260. These compounds have not been detected in Line 6B crude oil.

ERLs do not indicate that the analytes in question are present, only that the absence of a constituent above the Criteria, cannot be unequivocally established in that sample. Enbridge has used multiple lines of evidence to evaluate each ERL, to verify that it does not reflect exceedances that are attributable to the Line 6B crude oil release, for both groundwater and soil analytical results. ERLs are highlighted on the data tables provided, and are discussed in further detail in *Section 4.5.7*.

3.4.4 MDEQ Split Samples

Split samples from soil, groundwater, and surface water were collected by MDEQ personnel during the investigation phase of work. Soil samples were analyzed for VOCs, TPH, PNAs, Michigan 10 Metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc), and additional selected metals (beryllium, iron, molybdenum, nickel, and vanadium). Groundwater and surface water samples were analyzed for VOCs, TPH, PNAs, Michigan 10 Metals, and selected metals (beryllium, iron, molybdenum, nickel, and vanadium). MDEQ groundwater split samples were analyzed for dissolved (filtered) metals, in addition to total (unfiltered) metals. The MDEQ discontinued analysis of the Michigan 10 Metals in late 2011.

In October 2011, a comparison and evaluation of split and parent sample analytical results led to a modification in analytical methods for PNAs and TPH in the parent samples (i.e., Enbridge samples), which modified the sample drying process and resulted in closer agreement between the results of the split and parent samples. Both the MDEQ and Enbridge analytical laboratories followed the approved U.S. EPA analytical method; however, several drying methods are allowed under the approved procedure. The drying process used by the MDEQ laboratory was selected for use by both analytical laboratories for consistency. An evaluation of analytical results after this modification found an improved correlation between split and parent sample results, while accounting for typical analytical variation.

The analytical results from the split samples are included along with the parent sample results, in the data tables presented in this report. However, these results are for the purposes of data quality evaluations only, and are not to be compared to Criteria nor are they discussed in the body of the report.

3.4.5 Evaluation of Metals Associated with Line 6B Crude Oil

To address the infrequent occurrence of elevated metals concentrations reported in both soil and groundwater samples throughout the Spill Area, Enbridge prepared a report of findings entitled *White Paper: Evaluation of Metals in Soil and Groundwater*, submitted to the MDEQ on June 4, 2014 (Metals White Paper) (Enbridge, 2014c). The Metals White Paper was originally submitted as an attachment in both the *Reach 1 Remedial Investigation Report*, submitted to the MDEQ on February 28, 2014 (Enbridge, 2014d) and the *Reach 5 No Further Action Report*, submitted to the MDEQ on March 28, 2014 (Enbridge, 2014e). The Metals White Paper was subsequently revised (expanded) to include all of the backup data and information used to support the conclusions, as requested by the MDEQ and was resubmitted to the MDEQ on June 4, 2014 as a stand-alone document. *Attachment G* of this report contains a complete electronic copy of the Metals White Paper.

This evaluation targeted the four metals (beryllium, molybdenum, nickel, and vanadium) which were identified at low concentrations in the analysis of crude oil samples from the Line 6B pipeline by the MDEQ in 2010. The Metals White Paper uses multiple lines of evidence and the overwhelming preponderance of data to show that the metals present in soil and groundwater within the Spill Area are the result of natural conditions and are not the result of the Line 6B crude oil release. Lines of evidence include frequency of detections (or lack of), geographical distribution, comparison to background concentrations, presence of natural sources, lack of replication, and lack of co-occurrence with other, more reliable Line 6B crude oil indicators.

Tables in this RI report highlight sample results with concentrations of beryllium, molybdenum, nickel, and vanadium in excess of Part 201 Residential DWC. However, these results are not addressed in the text of this report as they are considered part of the natural variability of metals concentrations and not the Line 6B crude oil release.

It is Enbridge's position that sufficient data and evaluation has been completed and provided in the Metals White Paper to support the position that observed metal concentrations are not the

result of Line 6B crude oil. Enbridge requests that the MDEQ review the attached Metals White Paper and provide a meaningful technical response should they disagree with the scientific conclusions as presented.

3.5 Additional Studies

Based on discussions and agreements with the U.S. EPA (Notice to Enbridge dated March 7, 2011 (U.S. EPA, 2011)) and/or the MDEQ, Enbridge implemented advanced investigative techniques including: FLS, PI, Light Detection and Ranging (LIDAR), high-resolution UV photography/logging and high-resolution aerial photography.

3.5.1 Fluorescent Light Detection and Ranging System and Polarimetric Imagery

FLS and PI surveys were conducted from April 14 through and including April 17, 2011 in an attempt to identify remaining Line 6B crude oil signatures in the area impacted by the Line 6B crude oil release.

FLS can detect Line 6B crude oil based on matching the spectra produced by oil (in this case, specifically Line 6B crude oil) in response to light pulses from an overhead laser to the ground/surface. PI is the measurement and interpretation of the polarization of transverse light waves, relying on a change in polarimetric response to identify Line 6B crude oil.

The effective depth of both FLS and PI is limited to the ground surface; however, FLS may penetrate a water column up to 20 inches. The FLS and PI surveys were conducted from fixed-wing aircraft and a helicopter, respectively. Both surveys were conducted in the spring of 2011 when the leaves were off the trees and from multiple angles so the effects of tree cover were limited.

Several challenges were encountered during the PI survey, which were related specifically to the riverine environment. These included false positives caused by submerged logs, vegetation, and sand bars that changed the polarization state of the water and obscuration of the river by trees. Further, the approach of detecting oil based on polarization signature differences was designed for use in large bodies of water where slight differences can be detected and evaluated. It was not effective in the smaller and more complex riverine environment. The FLS survey did not detect any Line 6B crude oil UV fluorescence signatures within Reach 3. However, there were four notable PI observations. These PI observations occurred between MP 0.50 and MP 0.75, where two unconfirmed areas of

interest were identified along the shoreline at Polygon 3 right descending bank (RDB). Two additional unconfirmed areas of interest were identified approximately 275 ft and 400 ft upstream of MP 1.00. In addition, at one location during the PI surveys, oil sheen was observed on standing water within a wetland area. The onboard Enbridge representative visually confirmed the sheen on the water, but indicated it was a known area of biological sheen. At this time, studies have not been conducted with PI data to allow differentiation between naturally occurring biological sheen and that produced by crude oil. Copies of the FLS and PI reports are presented as *Attachment H*.

3.5.2 Light Detection and Ranging

In April of 2011, LIDAR was conducted to map the topographic details of the potentially impacted areas including; the Source Area, Talmadge Creek, and the Kalamazoo River. This information was critical in the development of an inundation model that was used to determine where Line 6B crude oil could have migrated while the river was at flood stage. The LIDAR data replaced outdated USGS information and enabled more accurate mapping of the Inundation Area.

3.5.3 High-Resolution Aerial Photography

In July 2011 and November 2011, high-resolution aerial digital orthophotography was conducted to capture precise images of the entire creek and river system from the Source Area to downstream of Morrow Lake in the Kalamazoo River. This aerial photography provided a scaled and detailed base image, which when coupled with the geographic information system database, allowed for the high quality and precise mapping of work and features associated with the project.

3.5.4 Field Screening Techniques

Various methods were used in the field to screen for the presence of Line 6B crude oil. Initial attempts in 2010 used a PID to screen the soils for the presence of VOCs that were present in the Line 6B crude oil diluent component, most of which had volatilize very soon after the release. It was concluded at that time, in agreement with the MDEQ, that the use of a PID would not reliably detect the presence of Line 6B crude oil in screening soils.

Beginning in 2011, in lieu of using the PID, the soils were screened with a UV light (specifically calibrated to the Line 6B crude oil “fluorescence signature”) and observed for oil fluorescence. The use of UV light proved to be effective as a screening technique and with some refinement

became the standard technique used to observe the presence of oil as part of the documentation methodology used for soil characterization.

3.6 Waste Management

Investigation and remediation--derived waste has been managed in accordance with the specific Waste Treatment, Transportation, and Disposal plan in place at the time the waste was generated. The plan currently in place is the *2013 Waste Treatment, Transportation, and Disposal Plan,* submitted to the U.S. EPA on September 16, 2013 (Enbridge, 2013e) and the *Addendum to the 2013 Waste Treatment, Transportation, and Disposal Plan,* submitted to the U.S. EPA on November 12, 2013 (Enbridge, 2013f).

The U.S. EPA and MDEQ were previously provided with copies of waste manifest/bill of lading documentation for the transport and disposal of waste materials. Wastes generated for multiple activities conducted on the project are managed per the approved plan and are not tracked by specific activity or location. Therefore, it is not possible to provide copies of manifests or bill of lading forms for waste disposal associated with specific activities described in this report. All project related wastes, including investigation-derived waste, are properly stored, characterized, transported, and disposed pursuant to all local, state, and federal regulations. Waste management documentation has been provided to the U.S. EPA and MDEQ.

4.0 Investigation Activities and Results

This section of the report presents a chronological summary of response, investigation and remediation activities, and investigation results for Reach 3. These activities included emergency response excavations and investigations, SORT activities, RI, remedial excavation activities, and a data gap evaluation. These activities were conducted on Reach 3 as outlined in *Section 1.3.*

4.1 Talmadge Creek Response Activities (2010)

In 2010, immediately following the Line 6B crude oil release, emergency response excavations were conducted adjacent to Talmadge Creek. These excavations were conducted under the direction of the U.S. EPA to recover visible Line 6B crude oil to the maximum extent practicable while maintaining the existing streambed. The work was conducted in accordance with the SAR; and the approved *Supplemental Source Area Response Plan* submitted to the U.S. EPA on October 17, 2010 (SSAR) (Enbridge, 2010e). During the excavation and following the restoration of the area, soil samples were collected to evaluate the effectiveness of the Line 6B crude oil recovery activities.

4.1.1 Talmadge Creek Response Excavation (2010)

Prior to excavation of the overbank soils, coir logs were placed adjacent to the creek banks to stabilize and preserve the streambed. Areas adjacent to the creek, which exhibited evidence of Line 6B crude oil, were then excavated. All excavation activities were conducted in accordance with the SAR and the SSAR.

Upon completion of the excavation, and prior to fill placement, a visual assessment was performed by personnel from Enbridge, U.S. EPA, and MDEQ. During the assessment, each bank of the creek was demarcated into 50-ft long sections and then independently evaluated for the presence of Line 6B crude oil and/or oil sheen. Test pits were excavated to assess the presence of Line 6B crude oil and/or oil sheen. If Line 6B crude oil and/or oil sheen were observed, additional excavation was conducted at that location. The Talmadge Creek streambed was not excavated during the fall of 2010 excavation effort. *Figure 6* includes the 2010 excavation areas and the corresponding U.S. EPA clearance category, noted as “A,” “B,” “C,” and “Special – Does not Meet A, B, or C Criteria”. The U.S. EPA provided clearance for each section where Line 6B crude oil recovery activities were completed as follows:

- A – Excavation to visual extent of Line 6B crude oil impact,
- B – Excavation to groundwater,
- C - Excavation to a geologic confining layer (clay or silt), or
- Special – Does not Meet A, B, or C Criteria (used when clearance was issued to a location, but conditions precluded excavation to criteria A, B, or C.

After the excavation was completed, approved clean fill was used to replace the excavated soil (using similar materials) and erosion control blankets (ECB) were placed over the fill materials to stabilize the wetland areas.

These excavation and restoration efforts were documented and submitted as the *Source Contamination Removal and Verification Summary Report Talmadge Creek: Section 1 to Section 10* submitted to the U.S. EPA on September 26, 2010 (Enbridge, 2010f). This document stated that all work completed for this section of Talmadge Creek met the U.S. EPA metrics and complied with the SAR and the SSAR. Therefore, no additional cleanup was necessary in this area to fulfill the U.S. EPA's requirements pursuant to the U.S. EPA Order.

4.1.2 Talmadge Creek 2010 Post Excavation Assessment

Because the 2010 Talmadge Creek excavation was conducted under the U.S. EPA Order, closure sampling under MDEQ protocol was not mandated. However, Enbridge elected to undertake post-excavation sampling in general accordance with the *MDEQ Sampling Strategies and Statistics Training Materials for Part 201 Cleanup Criteria,* issued by the MDEQ on August 2002 (S^3TM) (MDEQ, 2002). Post-excavation samples were collected in accordance with *SOP EN-304, Surface Soil Sampling*, as stated in the SAP and presented in *Attachment B*.

The post-excavation assessment was conducted within the Reach 3 Spill Area from August 29, 2010 through and including September 25, 2010. The assessment was conducted during and immediately following the excavation activities to evaluate their effectiveness. During this assessment, the MDEQ assisted Enbridge in selecting locations along Talmadge Creek for the collection of 263 post-excavation soil samples (locations PRB2-001 through and including PRB1-106, and PRB2.7 066 through and including PRB2.7 073) along with 8 duplicate and 22 regulatory split samples. At several of these locations, samples were collected prior to final excavation and backfilling activities in September 2010; however, additional sampling at these locations was performed immediately following the excavation

activities. The locations of the 2010 post-excavation soil samples are shown on *Figure 6.* Analytical results of the 2010 post-excavation assessment soil samples, including any duplicate and regulatory split sample analytical results are summarized in *Table 2*. Note that these 2010 activities were completed prior to the submittal and approval of the QAPP and SAP.

Review of the analytical results from the 2010 post-excavation assessment soil sampling reveals that although there were exceedances of DCC for arsenic and iron in some samples, none of the soil samples collected exhibited Criteria exceedances of spill-related constituents.

4.1.3 2010 Auxiliary Location Post-Excavation Assessment

As defined in the MDEQ Order, "Areas, places, and property that have been impacted by the Line 6B crude oil spill or response activities addressing the Line 6B crude oil spill, including but not limited to habitat, vegetation, soils, surface waters, sediments, groundwater, wetlands, floodplains, and overbank areas, are part of the Spill Area". In this document, those areas used during and affected by response activities addressing the Line 6B crude oil release are referred to as auxiliary sites or areas. Because these auxiliary areas are defined by the MDEQ to be part of the Spill Area, they required assessment. Auxiliary sites such as equipment staging areas (where impacted soil from excavations was staged prior to transport and off-site disposal), parking lots, boat launches, and mat roads (i.e., timber roads used to minimize impact to the ground surface), were evaluated due to the potential for impact by response activities. *Figure 7* depicts the location of each of these auxiliary areas.

In some cases, the auxiliary locations contained equipment such as fuel storage tanks, fractionation tanks, pumps, roll off containers, soil mixing equipment, lighting equipment, or water treatment systems. Activities conducted at auxiliary sites were carried out in a manner as to minimize, if not eliminate, the potential for releases of oil or hazardous materials to the environment. Soil mixing and staging areas were constructed with containment barriers such as tarps and liners. Small plastic swimming pools were routinely placed beneath equipment that contained fuel (i.e., light equipment and pumps), to capture any incidental releases of hazardous substances should they occur. While in operation, auxiliary sites were protected by a security contractor and were subject to daily inspections and reporting requirements. Any suspected release was immediately reported to Enbridge, where it was documented and the appropriate response action immediately implemented.

The primary auxiliary areas in Reach 3 during the 2010 excavation activities were mat roads, which were constructed to minimize impact to the ground surface by heavy equipment and to facilitate the excavation of impacted soils adjacent to Talmadge Creek. The mat roads were composed of timber mats, which were removed once the 2010 excavation was completed and the mat roads were no longer needed to perform excavation activities. As the timber mats were removed, the underlying soils were inspected for any stains by Enbridge and MDEQ representatives. In Reach 3, no stains were noted in the areas used for mat road.

During decommissioning, all auxiliary sites including mat roads were inspected by Enbridge and MDEQ representatives. If any signs of potential impact were observed during these inspections, Enbridge personnel collected soil samples for analysis and the associated GPS coordinates were recorded. Decommissioning of auxiliary areas included equipment and liner removal and the scraping and off-site disposal of the top 6 inches of soil, to address impacted soil, if present. Following decommissioning, surface soil samples were collected in general accordance with the S^3TM. Random surface soil samples were collected from grids, and biased surface soil samples were collected from former equipment usage areas. The objective of the soil sampling was to establish that auxiliary activities had not resulted in soil contamination.

Following the 2010 excavation activities, decommissioning within Reach 3 included the collection of soil samples at 23 locations (PE-B10031040 through and including PE-B10110958) and 8 duplicate soil samples (see *Figure 4*, *Figure 6*, and *Figure 7*). These samples were analyzed for metals (barium, molybdenum, nickel, and vanadium), moisture, PNAs, and VOCs. The analytical results are included in *Table 2.* Analytical results indicate that no exceedances of Criteria by Line 6B crude oil release-related compounds were detected.

4.1.4 Talmadge Creek Response Activities Conclusion

All work completed for Reach 3 met the U.S. EPA metrics, and complied with the SAR and the SSAR. No additional work activities were required in Reach 3 to fulfill the U.S. EPA's requirements under the U.S. EPA Order.

4.2 2011 Shoreline and Overbank Re-assessment Technique on Talmadge Creek

The following is a summary of the results of the 2011 SORT, which was conducted on the Reach 3 portion of Talmadge Creek. The Reach 3 SORT areas extended from MP 0.50 to I-69 and are presented on *Figure 5*.

SORT features were named using the following format: feature number followed by an I for Island (I), LDB for left descending bank (LDB), or RDB for right descending bank, (i.e. 1I, 1a LDB, or 1RDB). At the time of the 2011 SORT reassessment, the LDB of Talmadge Creek from MP 0.50 - MP 1.00 generally consisted of a re-engineered, low, vegetated bank with ECB covering the overbank and coir logs at the shoreline. The portion of the LDB from MP 1.00 to I-69 generally consisted of a re-engineered lawn with ECB covering the overbank and coir logs at the shoreline. The RDB of Talmadge Creek from MP 0.50 - MP 0.75 and from MP 1.00 to I-69 consisted of re-engineered low vegetated bank with ECB covering the overbank and coir logs at the shoreline. The portion of the RDB from MP 0.75 - MP 1.00 was similar; however, it also included an area of emergent/herbaceous wetlands.

The surface oiling descriptors used to characterize oil distribution and thickness during the SORT field activities were derived from those used in the NOAA *Shoreline Assessment Manual* (NOAA, 2000). The surface oil distribution (coverage) was defined as follows: continuous (91-100%), broken (51-90%), patchy (11-50%), sporadic (<1-10%), and trace (<1%). Oil thickness was defined as follows: pooled oil (> 1 centimeter (cm) thick), cover (from >0.1 cm to <1 cm on any surface), coat (visible oil <0.1 cm, which can be scraped off with fingernail), stain (visible oil, which cannot be scraped off with fingernail), and film (transparent or iridescent sheen or oily film).

The SORT field observations were compiled onto SORT sign-off sheets, which were reviewed and subsequently approved by START, MDEQ, and Enbridge personnel. The applicable SORT sign-off sheets for Reach 3 contain signatures from all parties, which indicate that the segments of Talmadge Creek from MP 0.50 - MP 1.25 were adequately reassessed and documented. The sign-off sheets are presented in *Attachment C*. No recommendations for SORT follow-up activities were documented for the RDB or LDB of Reach 3 and therefore no follow-up assessment was conducted on Reach 3 during the 2012 SORT Reassessment activities.

4.2.1 Shoreline and Overbank Re-assessment Technique Results – Left Descending Bank

In the section of Talmadge Creek from MP 0.5 - MP 0.75, the reassessment identified four points on the LDB. A trace or sporadic occurrence of film on ponded water was identified at Points 1 LDB, 1a LDB, and 2 LDB; and, a patchy occurrence of film on ponded water was identified at Point 2a LDB. From MP 0.75 – MP 1.00 of the LDB, the reassessment did not identify any evidence of Line 6B crude oil on the LDB and was documented by one additional point (1 LDB) indicating this section was evaluated and found to be free of Line 6B crude oil. Two points and two polygons were identified on the LDB of Talmadge Creek from MP 1.00 to I-69. A trace or sporadic occurrence of film on ponded water was identified at these locations.

4.2.2 Shoreline and Overbank Re-assessment Technique Results – Right Descending Bank

On the RDB of Talmadge Creek from MP 0.50 - MP 0.75, the reassessment identified three points and three polygons. A trace or sporadic occurrence of film on ponded water was identified at all six locations. From MP 0.75 - MP1.00, on the RDB, the reassessment identified three points and one polygon. A trace or sporadic occurrence of film on ponded water was identified at these locations. One point and one polygon were identified on the RDB of Talmadge Creek from MP 1.00 to I-69. In that section, a trace or sporadic occurrence of film on ponded water was identified at Point 1a RDB and Polygon 1 RDB.

4.3 Talmadge Creek Remedial Investigation

Prior to the 2012 excavation of the Talmadge Creek channel, the TCRI was conducted in late 2011 and early 2012. Follow-up sampling to investigate data gaps was conducted in early 2014. The TCRI included sampling of soil, sediment, and groundwater; visual observation for oil sheen; and, screening for oil in the soil matrix using UV fluorescence. The goal of the TCRI was to gather sufficient information to define the nature and extent of remaining impacts from the release of Line 6B crude oil to the sediment and floodplain area, and to identify areas where additional cleanup of remaining Line 6B crude oil release material was required along Talmadge Creek. The TCRI was conducted on this portion of Talmadge Creek commencing on September 12, 2011. Field and laboratory sampling and analytical methods were performed in accordance with the RIWP. *Attachment I* contains the laboratory analytical reports from this effort.

4.3.1 Soil Analytical Results

In September 2011, October 2011, January 2012, and January 2014 through and including March 2014, a total of 787 soil samples (plus 69 duplicate samples and 144 regulatory split samples) were collected from stream bank and floodplain areas in the Reach 3 Spill Area. The September and October 2011 samples were collected to define the vertical and lateral extent of Line 6B crude oil impact in soil within the Reach 3 Spill Area. The purpose of the soil borings advanced in January 2012 was to further quantify observed impacts at five specific locations, as specified in the RIWP Supplement. Three of these five locations (SBTC0100R092, SBTC0100R092C, and SBTC0100R092E) were located within a wetland area on the north side of Talmadge Creek, approximately half way between MP 0.75 and MP 1.00. Two of the five borings (SBTC0125R012A and SBTC0125R012B) were located on the north side of the creek (at the bend just past MP 1.00) and were installed to resample locations where impacts had previously been observed. Additional samples were collected in early 2014, to address data gaps that had been identified in the existing data set.

The analytical results from these samples were compared to relevant Criteria. However, as agreed upon with the MDEQ, the analytical results for sediment and saturated soil samples are compared only to DCC.

Figure 8 depicts the sample locations and *Table 3*, *Table 4*, and *Table 5* present tabulated summaries of the unsaturated, saturated, and synthetic precipitation leaching procedure (SPLP) analytical data, respectively.

Review of the analytical results from the 2011-2012 TCRI soil sampling reveals that two VOCs (chloromethane and trichloroethylene (TCE)) were detected above Criteria, in three soil borings along Talmadge Creek. None of the samples exceeded Criteria for VOCs associated with the Line 6B crude oil. The exceedances that were detected in samples are as follows:

- Chloromethane: exceeded Criteria in one sample location (SBTC0100R524) at a concentration of 2,500 micrograms per kilogram (ug/kg), exceeding the SVIAIC of 2,300 ug/kg.
- TCE: exceeded Criteria in one sample location (SBTC0075L508) at a concentration of 810 ug/kg, exceeding the DWPC of 100 ug/kg.

- SPLP TCE: exceeded Criteria in two sample locations (SBTC0075L508 and SBTC0100R501) at concentrations of 10 micrograms per liter (ug/l) and 6.2 ug/l, respectively, exceeding the DWC of 5 ug/l.

Chloromethane was not detected in Line 6B crude oil. Further, chloromethane is a highly volatile gas with a boiling point of approximately -20°C (-4°F): therefore, any releases to surface soil would be expected to evaporate immediately. In addition, a review of all soil samples collected historically throughout the entire Spill Area, reveals that a total of 37 results of chloromethane were detected above the RL. Of these 37 results, 14 (39%) were flagged by the laboratory, indicating that Chloromethane was detected in the laboratory blank and that it was determined not to be associated with the field sample. Due to these factors, it is presumed that chloromethane detections are laboratory artifacts and that chloromethane is not actually present in field soil samples.

While TCE was not detected in the Line 6B crude oil, it may or may not be related to response activities completed in the Spill Area. However, it is significant to note that the location of this TCE exceedance is adjacent to a pipeline utility corridor and it is possible that the source is related to other historic work previously completed in the area. Regardless, further investigation into the low level detection of TCE has demonstrated no potential risk to human health.

4.3.2 Sediment Analytical Results

As part of the SOTF investigation conducted in the fall of 2010, a total of 30 sediment samples (plus 2 duplicates) were collected from 11 sampling locations within the Reach 3 channel of Talmadge Creek. Sediment samples were collected in accordance with *SOP EN-202, Sediment Sampling*, as stated in the SAP and presented in *Attachment B*. In addition, 11 sediment samples were collected from 3 locations (SETC0125C001 through and including SETC0125C003) during the period from October 3, 2011 through and including October 4, 2011, as part of the TCRI, to delineate the potential vertical and lateral extent of remaining Line 6B crude oil within the sediment. An additional three samples were collected from 3 locations (SETC0100C501, SETC0100C502, and SETC0100C503) in early 2014, to address data gaps that had been identified in the existing data set. *Figure 9* depicts the sample locations. *Table 6* presents a tabulated summary of the analytical results from sediment samples collected from Talmadge Creek.

A comparison of the results in *Table 6* to Criteria shows that there were no exceedances of DCC in any of the sediment samples. In addition, the majority of these sediment sample locations were subsequently excavated during the 2011-2012 streambed excavation of Talmadge Creek.

4.3.3 Groundwater Analytical Results

During the TCRI in 2011, 77 representative groundwater samples were collected (including 7 duplicate samples and 6 regulatory split samples), as presented on *Figure 10*. Temporary wells were installed in 10% of the floodplain and SORT investigation locations. Two temporary wells were installed at each selected location. One temporary well was installed to the termination of the boring to sample groundwater at depth and a second well was installed to obtain a sample at the water table. In January 2012, two additional temporary wells were installed and sampled to further define potential impacts previously observed in two areas. These locations were specified in the RIWP Supplement. One of the temporary wells was installed within a wetland area located on the north side of Talmadge Creek, approximately half way between MP 0.75 and MP 1.00. The other temporary well was installed on the north side of the creek, slightly west of MP 1.00 (*Figure 10*). An additional 71 groundwater samples (including 7 duplicate samples) were collected as part of the Data Gap Assessment that was conducted in 2014, as presented on Figure 10.

As is typical for temporary wells, the wells were not developed. The wells were purged prior to sampling, which typically occurred within 24 hours to 48 hours of installation. Groundwater was sampled and field parameter values were collected in accordance with the RIWP using the low flow techniques described in that document. After the collection of groundwater samples, the temporary wells were removed and the boreholes were backfilled to the ground surface with bentonite pellets. The low flow sampling forms from this sampling are provided in *Attachment E.*

Table 7 presents a tabulated summary of the analytical results from groundwater samples, and sample locations are shown on *Figure 10*. In several of the temporary wells, insufficient water was produced to measure field parameters. In three of the temporary wells (SBTC0075R002, SBTC0075R013, and SBTC0100R091), there was an insufficient volume of water to collect samples.

A comparison of the groundwater analytical results in *Table 7* to Criteria shows there were no exceedances by any VOCs or PNAs in any of the groundwater samples. The quality or groundwater at and beneath Talmadge Creek was further evaluated following the 2012 excavation. *Section 4.5.4* summarizes the findings of the Data Gap assessment, which describes the results of this work.

4.3.4 Surface Water Results

During the TCRI in September 2011, four surface water samples (plus one duplicate and one regulatory split sample) were collected from a wetland area situated north of Talmadge Creek between MP 0.75 and MP 1.00. These surface water samples were collected to evaluate the groundwater discharge from an area located adjacent to the RDB of Talmadge Creek at approximately MP 0.90 (*Figure 10*). Surface water samples were collected using a peristaltic pump and disposable tubing as described in the *SOP EN-201, Surface Water Sample Collection* as stated in the SAP and presented in *Attachment B*. No surface water samples were collected from within Talmadge Creek proper during the TCRI.

A comparison of surface water analytical results presented in *Table 8* to Criteria shows there were no exceedances by any VOCs or PNAs in any of the samples.

4.4 Talmadge Creek Excavation (2011 – 2012)

Results from the TCRI were used to develop the 2011 and 2012 excavation boundaries. The excavation activities took place from November 2011 through and including early March 2012 in accordance with the following approved work plans, *Talmadge Creek Excavation Work Plan MP 0.50 – MP 1.00*, submitted to the MDEQ on December 7, 2011 (Enbridge, 2011c) and *Talmadge Creek Excavation Work Plan MP 1.00 - MP 2.25*,submitted to the MDEQ on February 16, 2012 (Enbridge, 2012a).

The primary goal of this effort was to remove Line 6B crude oil impacted soil and sediment identified during previous work in 2010 and 2011, and to replace existing coir logs that were installed in 2010. The streambed sediments, several selected overbank areas, and portions of the adjacent wetland were excavated (including removal of impacted vegetation). Mat roads were used to gain access directly adjacent to the proposed excavation areas. Use of mat roads was minimized to the extent practicable to complete the work and mats were placed, where possible, at locations used previously during 2010 response and 2011 investigation activities.

Appropriate soil erosion and sedimentation controls (e.g., silt fence, etc.) were installed around the perimeter of the excavation, support, and staging areas prior to removal activities. Sheet piling was placed to maintain creek bed stability during coir log removal and to isolate the excavation area from adjacent seeps. Water diverted from the creek during excavation was subject to sedimentation control devices such as filter bags, sediment filter boxes, or similar devices. Excavation and restoration activities for each excavation section were completed by the end of each day as field conditions allowed. An excavator or other comparable equipment was used to excavate the oil-impacted soil and sediment. Surficial impact areas on the overbank were removed using approved methods (i.e., hand scraping and shoveling). If these methods proved ineffective, additional excavation was performed using an excavator or comparable equipment.

The MDEQ and U.S. EPA assisted Enbridge with the visual delineation of the excavation, both laterally and vertically. During this excavation, many previous sample locations from the 2010 post-excavation sampling event and the 2011 TCRI were excavated. *Figure 8* depicts the boundary of the excavation, which included the streambed. *Figure 8* also shows the depth of the excavation, which in most areas was 2 ft or less, but ranged up to 8 ft in limited areas downstream from MP 1.00. A total of approximately 3,200 cubic yards of materials were removed from a total area of 50,000 square feet in the Reach 3 Spill Area during the 2011-2012 excavation. Excavation activities were conducted until no Line 6B crude oil was observed. The excavation was backfilled with clean fill and restored following the excavation.

Enbridge conducted post excavation sampling in general accordance with the S^3TM guidance and the approved *Analytical Sampling Approach at Excavation Sites Memorandum*, submitted to the MDEQ on December 21, 2011 (Enbridge, 2011g). More specifically, post excavation samples were collected as follows:

- Soil samples were collected from the excavation floor and sidewalls in areas above the normal level of water saturation,
- Excavation floor samples were not collected if the excavation extended below the normal (non-dewatered) level of groundwater saturation,
- Representative groundwater samples were collected from the excavation floor if dewatering activities were successful in preventing the influx of creek water, and

- Water from normally saturated sediments was sampled in lieu of soil samples through the construction of a small sampling sump, which accumulated water that seeped into the excavation.

Although sampling frequency is not defined under the S^3TM guidance document, samples were intended to be representative of excavated conditions. Therefore, samples were collected at the rate of one sample per excavation for smaller excavations, and one per day for larger excavations. The samples were collected from November 2011 through and including March 2012, to evaluate the effectiveness of the remedial activity. A total of 127 post excavation soil samples (plus 7 duplicates and 16 regulatory split samples) and 4 excavation water samples were collected from the excavated areas in accordance with the sampling strategy outlined above.

4.4.1 Soil Analytical Results

The 2011-2012 post excavation unsaturated soil, saturated soil, and SPLP data are presented in *Table 9*, *Table 10*, and *Table 11*, respectively. Review of the analytical results from the 2011-2012 soil sampling collected following the excavation indicated that one of two VOCs (chloromethane and toluene) were detected above Criteria, in two separate soil samples. Only the sample from ESTC0100R154 exceeded Criteria for any VOCs associated with the Line 6B crude oil. The exceedances that were detected in samples are as follows.

- Chloromethane- exceeded Criteria in one sample (at location ESTC0100L138) at a concentration of 6,200 ug/kg, exceeding the DWPC of 5,200 ug/kg and the SVIAIC of 2,300 ug/kg.
- Toluene- exceeded Criteria in one sample (at location ESTC0100R154) at a concentration of 8,600 ug/kg, exceeding the GSIPC of 5,400 ug/kg.

Additional groundwater sampling was performed in the area of ESTC0100R154, which indicated no groundwater Criteria exceedances in this location. A description of this sampling is presented in *Section 4.5.4*.

Chloromethane is a highly volatile gas that was not detected in Line 6B crude oil. In addition, 39% of the chloromethane detects were associated with laboratory blank detections. As a result, it is presumed that chloromethane detections are laboratory artifacts. Additional discussion of this analyte is presented in Section *4.3.1*. The low-level toluene detection was further investigated and demonstrated no potential risk to human health.

4.4.2 Groundwater Analytical Results

Four groundwater samples and one groundwater regulatory split sample were collected during the 2011 excavation activities in general accordance with the sampling strategies outlined in the S^3TM guidance document. The water samples were collected from excavations with standing groundwater, in accordance with *Section 280.72* of the Michigan Underground Storage Tank Rules since no formal guidance exists for Part 201.

Table 12 presents a tabulated summary of the analytical results from groundwater samples and sample locations are shown on *Figure 10.* A comparison of the groundwater analytical results in *Table 12* to Criteria shows there were no exceedances of any VOCs or PNAs in any of the groundwater samples.

4.4.3 2013 Auxiliary Location Post-Excavation Assessment

The auxiliary areas used in Reach 3 during the 2011 excavation activities included: lighting systems; generators for powering lighting systems; dewatering pump areas (generators, fuel tanks, pumps, fractionation tanks, granular activated carbon water treatment equipment); drum storage areas; excavated soil mixing stations; mat equipment staging areas; decontamination/staging area; clean soil staging area; treated water discharge areas; and, mat roads.

During decommissioning, all auxiliary sites including former mat roads were inspected by Enbridge and MDEQ representatives. If any signs of potential impact were observed during these inspections, Enbridge personnel collected soil samples for analysis and the associated GPS coordinates were recorded. Decommissioning of auxiliary areas included equipment removal, liner removal, and the scraping/off-site disposal of the top 6 inches of soil to remediate impacted soil, if present. Following decommissioning, surface soil samples were collected in general accordance with the S^3TM. Random surface soil samples were collected from grids, and biased surface soil samples were collected from former equipment usage areas. The objective of the soil sampling was to establish that auxiliary activities had not resulted in soil impact.

In January 2013, decommissioning activities within Reach 3 included the collection of 15 soil samples and 2 duplicate soil samples from support areas utilized during the 2011-2012 excavation activities (see *Figure 4* and *Figure 7*). The analytical results are included in

Table 13. Analytical results indicate that no Criteria exceedances by site-related compounds were detected.

4.5 2014 Data Gap Assessment

This section discusses data gaps that have been identified in the Reach 3 Spill Area. This discussion first addresses each data gap category in general, and then presents a point-by-point evaluation of each data gap to demonstrate how data gaps were closed. There are no remaining data gaps in Reach 3.

On August 9, 2013, Enbridge submitted the *Draft No Further Action Report Reach 3 – MP 0.50 to MP 1.00*, to the MDEQ for review and discussion (Enbridge, 2013g). Subsequently, Enbridge and the MDEQ identified a series of sampling locations where analytical results exceeded Criteria, or where limited data did not fully assess the effectiveness of the response activities that were conducted in 2011 and/or 2012. These locations have been referred to as data gaps. The data gaps identified in the Reach 3 Spill Area involved various constituents and areas including: visual observations, trace UV fluorescence, UV fluorescence, VOC and PNA verification, molybdenum, 2011 excavation delineation, the Wolverine and Panhandle pipeline area, and ERLs. The visual observation descriptors used to characterize oil distribution and thickness during the field activities were derived from those used in the NOAA *Shoreline Assessment Manual* (NOAA, 2000). The surface oil distribution (coverage) was defined as follows: continuous (91-100%), broken (51-90%), patchy (11-50%), sporadic (<1-10%), and trace (<1%). UV fluorescence distribution observations were characterized as trace if UV fluorescence appeared in less than 1% of the soil core.

To address the data gaps, a series of 82 soil borings were advanced and 63 temporary wells were installed and sampled at the locations shown on *Figure 11*.

4.5.1 Visual Surficial Observations

Visual inspections were proposed at pre-determined locations in the investigation area where historic information (e.g., MDEQ notes, boring logs from coring crews during response activities, etc.) indicated a potential for residual impact that had not been fully addressed. For the purposes of this RI report, only areas with previous notations of surface sheen and/or visual impacts were inspected.

On April 1, 2014, 17 locations were revisited and visually inspected for surficial impacts to evaluate current site conditions. Inspected locations were as follows.

RDB

- SBTC0075R004
- SBTC0100R009A
- SBTC0100R092G

LDB

- SBTC0075L005
- SBTC0075L014
- SBTC0075L019
- SBTC0075L042
- SBTC0100L053
- SBTC0100L073
- SBTC0100L074
- SBTC0100L080A
- SBTC0100L080B
- SBTC0100L084A
- SBTC0100L087
- SBTC0100L090
- SBTC0100L090A
- SBTC0125L002

In addition to the 17 targeted visual surficial inspections noted above, all 2014 data gap assessment soil boring and temporary well locations were also inspected for visible surficial impacts. There were no surficial impacts noted at any of the locations during the 2014 data gap assessment at Reach 3.

4.5.2 Trace Ultraviolet Fluorescence Sampling

Follow-up data gap soil borings were conducted at locations where historic information (e.g., MDEQ review, response activities, etc.) indicated the potential for remaining impact (in the form of trace UV fluorescence) that had not been fully addressed. The selected locations had trace UV fluorescence previously observed but were lacking associated analytical data. As agreed upon with the MDEQ, samples to address this data gap were collected from

approximately one-third of these previously noted trace UV fluorescence locations. Soil boring locations are shown on *Figure 8*.

A total of 18 trace UV fluorescence locations were chosen for further investigation. These locations were intentionally biased to investigate locations where there were other Line 6B crude oil observations or a lack of analytical laboratory data. Soil samples were collected at these locations from the same depth intervals at which previous observations of trace UV fluorescence had been recorded. The resulting soil samples were analyzed for metals, PNAs, and VOCs. The following are the original boring locations with the follow-up data gap sampling locations in parenthesis.

RDB

- SBTC0075R020 (SBTC0075R502)
- SBTC0075R052 (SBTC0075R504)
- SBTC0075R070 (SBTC0075R506)
- SBTC0100R016 (SBTC0100R506)
- SBTC0100R060 (SBTC0100R508)
- SBTC0100R067A (SBTC0100R511)
- SBTC0100R073A (SBTC0100R514)
- SBTC0100R031A (SBTC0100R517)
- SBTC0100R038 (SBTC0100R519)
- SBTC0100R041 (SBTC0100R520)
- SBTC0125R006 (SBTC0125R501/506)
- SBTC0125R023 (SBTC0125R507)

LDB

- SBTC0075L032 (SBTC0075L503)
- SBTC0075L038A (SBTC0075L504)
- SBTC0100L064 (SBTC0100L510)
- SBTC0100L089 (SBTC0100L506)
- SETC0100C003 (SBTC0100C501)
- SBTC0100L098A (SBTC0100L505)

Only one of the follow-up trace UV fluorescence data gap samples (SBTC0075R502) exhibited trace UV fluorescence further demonstrating that the occurrence of UV fluorescence is sporadic, deminimus, and disconnected. The original soil sample from this location (SBTC0075R020) collected in September 2011, at the 0 ft to 0.6 ft depth interval, had trace UV fluorescence observed but no analytical sample was collected and the location was not excavated. In January 2014, a boring was advanced at SBTC0075R502 outside of the 2011 excavation boundary, near the location of the previous soil boring SBTC0075R020. Trace UV

fluorescence was noted and an unsaturated soil sample was collected from SBTC0075R502. This location had ERLS for PNAs and VOCs. A temporary well was not installed at the time of the sample collection at this location; however, a temporary well was installed approximately 20 ft southwest of SBTC0075R502 at location SBTC0075L516. The groundwater sample from SBTC0075L516 reported non-detect results for all PNAs and VOCs, indicating the ERLs noted in SBTC0075R020 and SBTC0075R502 have not resulted in exceedances of groundwater Criteria.

There were no analytical exceedances of Criteria at any of the 18 trace UV fluorescence locations sampled. Results from the 2014 sampling indicate trace UV fluorescence observations visible under UV fluorescence are sporadic, deminimus, and disconnected and therefore are not indicative of a risk to human health or environment.

Table 3 and *Table 4* include tabulated summaries of the unsaturated and saturated analytical soil results, respectively. *Table 7* includes the groundwater analytical results.

4.5.3 Ultraviolet Fluorescence Sampling

Follow-up data gap soil borings were conducted at locations where historic information (e.g., MDEQ review, response activities, etc.) indicated a potential for remaining impact (in the form of UV fluorescence) that had not been fully addressed. The selected locations had UV fluorescence previously observed but were lacking associated analytical data. As agreed upon with the MDEQ, additional follow up samples were collected from all of these UV fluorescence locations to address this data gap. Soil boring locations are depicted on *Figure 8*.

Twenty-nine UV fluorescence locations were investigated. Soil samples were collected at these locations from the same depth intervals at which previous observations of UV fluorescence had been recorded. The resulting soil samples were analyzed for metals, PNAs, and VOCs. Temporary wells were installed and groundwater was sampled at 21 of these locations to evaluate groundwater quality related to these observances. The following are the original boring locations with the follow-up data gap sampling locations in parenthesis.

RDB

- SBTC0075R015 (SBTC0075R501)
- SBTC0075R070 (SBTC0075R506)

LDB

- SBTC0075L040A (SBTC0075L514)
- SBTC0075L072 (SBTC0075L505)

- SBTC0100R001 (SBTC0100R501)
- SBTC0100R008 (SBTC0100R503)
- SBTC0100R013 (SBTC0100R504/524)
- SBTC0100R037A (SBTC0100R518)
- SBTC0100R063 (SBTC0100R509)
- SBTC0100R067 (SBTC0100R510)
- SBTC0100R069 (SBTC0100R512)
- SBTC0100R073 (SBTC0100R513)
- SBTC0100R076 (SBTC0100R515)
- SBTC0100R077A (SBTC0100R516)
- SBTC0100R092C (SBTC0100R521)
- SBTC0100R092 (SBTC0100R522)
- SBTC0125R008 (SBTC0125R502)
- SBTC0125R023 (SBTC0125R507)
- SBTC0100L005 (SBTC0100L501/512)
- SBTC0100L006 (SBTC0100L502)
- SBTC0100L044A (SBTC0100L503)
- SBTC0100L058A (SBTC0100L504)
- SBTC0100L075 (SBTC0100L509)
- SBTC0100L084 (SBTC0100L508)
- SBTC0100L086 (SBTC0100L507)
- SBTC0100L089 (SBTC0100L506)
- SBTC0125L019 (SBTC0125L503)
- SBTC0125L021 (SBTC0125L502)
- SETC0100C005 (SBTC0100C502)

During the 2014 data gap evaluation, there were UV fluorescence observations at 3 of the 29 locations:

- SBTC0100L006 (SBTC0100L502)
- SBTC0100L075 (SBTC0100L509)
- SBTC0075L040A (SBTC0075L514)

There were no analytical exceedances of soil Criteria at these three locations, further demonstrating that the occurrence of UV fluorescence is sporadic, deminimus, and disconnected.

Although UV fluorescence was not noted in boring SBTC0100R524, chloromethane exceeded the SVIAIC (2,300 ug/kg) in this soil sample (2,500 ug/kg) collected at the 0 ft to 1 ft interval. However, at the nearby soil sampling location ESTC0100R146 (less than 5 ft to the northwest), a soil sample collected at 1.5 ft was non-detect for chloromethane.

Chloromethane is a highly volatile gas that was not detected in Line 6B crude oil. In addition, 39% of the chloromethane detects were associated with laboratory blank detections. As a result, it is presumed that chloromethane detections are laboratory artifacts. Additional discussion of this analyte is presented in Section *4.3.1*.

There were no exceedances of groundwater Criteria at any of the follow-up data gap UV fluorescence locations. Results from the 2014 sampling indicate UV fluorescence observations visible under UV fluorescence are sporadic, deminimus, and disconnected and are not indicative of a risk to human health or environment.

Table 3 and *Table 4* include tabulated summaries of the unsaturated and saturated analytical soil results, respectively. *Table 7* includes the groundwater analytical results

4.5.4 VOC and PNA Exceedance Verification Sampling

Verification sampling was conducted during the 2014 data gap assessment based on historical analytical results indicating exceedances of Criteria for VOCs and/or PNAs. These exceedances could have indicated the presence of a remaining impact not fully addressed by the previous remedial excavations. Soil samples were collected and temporary wells were installed at these data gap locations to obtain verification groundwater samples, as presented in *Figure 8*. There were four historical locations where VOCs or PNAs analytical results exceeded Criteria. Therefore, during the 2014 data gap analyses, samples were collected at these locations:

RDB

- ESTC0100R154 (SBTC00100R507)
- SBTC0125R503

LDB

- SBTC0075L508
- ESTC0100L138 (SBTC0100L511)

Boring SBTC0075L508 was installed south of the Panhandle Eastern Pipeline on the LDB to evaluate the area because there were no previous samples collected in the immediate area. The soil sample collected at this location on January 30, 2014 from a depth of 0.2 ft to 0.7 ft bgs reported an analytical result for TCE of 810 ug/kg (above DWPC of 100 ug/kg) and a TCE SPLP result of 10 ug/l (above DWC of 5 ug/l). An additional soil sample was collected at this location on February 17, 2014 from the same depth profile. The later sample had an ERL for TCE of < 320 ug/kg and an SPLP of < 1.0 ug/l. A temporary well was also installed at this location on February 17, 2014 and a groundwater sample was collected at the water table.

The groundwater sample results from location SBTC0075L508 were non-detect for all PNAs and VOCs including TCE, indicating that constituents are not leaching from soil to groundwater at this location.

Toluene was detected in sample ESTC0100R154 (January 20, 2012 post-excavation soil) at a concentration of 8,600 ug/kg at a depth of 2 ft bgs, exceeding the GSIPC of 5,400 ug/kg. This location was identified as a data gap and was further investigated as part of the 2014 data gap sampling. Data gap sample SBTC00100R507 was collected on January 21, 2014 and is located immediately adjacent to ESTC0100R154. No visual or UV fluorescence evidence of oil was observed in this boring, which extended to a depth of 3.8 ft bgs. Saturated conditions were noted at a depth of 1.6 ft bgs; therefore, a soil sample was not collected from the target depth of 2 ft bgs. A temporary well was installed at this location on February 18, 2014 and a groundwater sample was collected and analyzed for VOCs from the screened interval of 0.5 to 4.0 ft. Analytes were below detections limits with the exception of toluene, which was detected at 1.8 ug/l. No exceedances of Criteria were detected in this groundwater sample. This result indicates that the ESTC0100R154 soil sample GSIPC exceedance has not resulted in a Criteria exceedance in groundwater.

There were no other exceedances of Criteria in the VOC and PNA verification data gap soil and groundwater samples. *Table 3* and *Table 4* include tabulated summaries of the unsaturated and saturated analytical soil results, respectively. *Table 7* includes the groundwater analytical results. These results show that there are no continuing data gaps related to VOC and/or PNA exceedances, and there is no remaining risk to human health in these locations.

4.5.5 2011 Excavation Delineation Sampling

As described in *Section 4.4*, during the 2011 excavation in the Reach 3 Spill Area, Enbridge elected to undertake post-excavation sampling in general accordance with the S^3TM guidance. Following the review of the resulting data, soil borings were proposed at pre-determined locations in the investigation area where historic information indicated a potential for data gaps in the excavation delineation sampling. During 2014, soil samples were collected at 13 locations to delineate the 2011 excavations.

RDB

- SBTC0075R015 (SBTC0075R501)

LDB

- SBTC0075L501

- SBTC0075R511
- SBTC0075R516
- SBTC0100R007 (SBTC0100R502)
- SBTC0100R012 (SBTC0100R505)
- SBTC0100R013 (SBTC0100R524)
- SBTC0100R067 (SBTC0100R510)
- SBTC0100R073 (SBTC0100R513)
- SBTC0125R008 (SBTC0125R502)

- SBTC0075L025 (SBTC0075L502)
- SBTC0075L510
- SBTC0100L005 (SBTC0100L512)

Excavation delineation sampling locations are presented on *Figure 8, Figure 9, and Figure10*. There were no exceedances, above Criteria in these samples, and there is no remaining risk to human health associated with these locations. *Table 3* and *Table 4* include tabulated summaries of the unsaturated and saturated analytical soil results, respectively. *Table 7* includes the groundwater analytical results.

4.5.6 Wolverine and Panhandle Pipeline Sampling

Due to early access limitations in the vicinity of these pipelines, samples were collected at 12 locations to characterize the areas around the Wolverine and Panhandle Pipeline crossings.

RDB

- SBTC0075R510
- SBTC0075R511
- SBTC0075R512
- SBTC0075R513
- SBTC0075R514

LDB

- SBTC0075L506
- SBTC0075L507
- SBTC0075L508
- SBTC0075L509
- SBTC0075L510
- SBTC0075L512
- SBTC0075L513

Wolverine and Panhandle pipeline sampling locations are presented on *Figure 8, Figure 9,* and *Figure 10*. As discussed in *Section 4.5.4*, soil samples collected at SBTC0075L508

reported analytical results that exceeded DWPC for TCE. However, groundwater sample results from SBTC0075L508 were non-detect for TCE, indicating that constituents are not leaching from soil to groundwater in this location.

There were no other exceedances of Criteria in these soil and groundwater samples. *Table 3* and *Table 4* include tabulated summaries of the unsaturated and saturated analytical soil results, respectively. *Table 7* includes the groundwater analytical results. These results show there are no continuing data gaps related to these locations, and therefore there is no remaining risk to human health in these locations.

4.5.7 Elevated Reporting Limits

As previously stated in *Section 3.4.3*, an ongoing challenge on this project, has been the presence of ERLs that exceed Criteria in soil samples. More specifically, of the 372 unsaturated soil samples with analytical results in Reach 3, 65% had ERLs that exceed Criteria for one or more VOC or PNA analytes typically associated with Line 6B crude oil. While ERLs do not indicate that analytes exceed Criteria, it cannot be presumed that these analytes are below Criteria in samples with ERLs above Criteria. Thus, the need to establish a process to identify those samples with ERLs that potentially reflect exceedances attributable to the Line 6B crude oil release and thereby require individual evaluation and/or potential additional field investigations.

This section describes the process Enbridge used to identify those locations that had ERLs that required specific evaluation and in some cases additional sampling. This section also provides details on specific samples that have been collected to address this data gap.

4.5.7.1 Elevated Reporting Limit Evaluation Process

ERLs were noted for a number of constituents, most commonly VOCs and occasionally PNAs as highlighted in the analytical tables presented in this report. For the purposes of this evaluation and to maintain the focus on constituents attributable to the Line 6B crude oil release, the 2014 data gap assessment included only ERLs of VOCs and PNAs associated with the Line 6B crude oil that exceeded Criteria.

In order to focus on ERL data gaps, Enbridge developed a process that included a line of evidence approach to identify and address potential data gaps that could not be evaluated with the existing data. The following is a description of this process:

- A thorough review of all Reach 3 Spill Area analytical data was performed. The review showed that ERLs associated with both saturated soil and groundwater samples were nearly always limited to two constituents (dibromochloropropane and ethylene dibromide). No other ERLs above DCC were observed in saturated soil and groundwater within Reach 3. These constituents are not attributable to Line 6B crude oil (see *Section 3.4.3* for further discussion of these compounds).
- Any unsaturated soil sample collected from a location that was subsequently excavated was eliminated from further evaluation. This specifically eliminated those sample locations along Talmadge Creek that were collected shortly after the Line 6B crude oil release, but were subsequently excavated.
- The remaining unsaturated soil sample locations with ERLs that exceed Criteria were then evaluated on an individual basis. Samples were also eliminated as potential ERL data gaps if they were collected from locations not relied upon for compliance purposes, or if they only marginally exceeded the relevant Criteria.

Following completion of this process, Enbridge evaluated each remaining individual ERL against the following lines of evidence to determine the need, if any, for additional site characterization to assess ERLs. This approach was discussed and presented to the MDEQ during meetings held on January 9, 2014 and January 16, 2014. The MDEQ concurred that this was an appropriate manner in which to address ERLs.

- Representative Groundwater Data – Since DWPC and GSIPC were the Criteria associated with ERLs, it was decided that if a representative groundwater result, with no exceedance of the Criteria in question, was located within approximately 25 ft of the sample with an ERL, then the ERL would not be considered a data gap. For the purposes of this evaluation, representative groundwater samples include those collected from monitoring wells, temporary wells, and excavations.
- Representative Soil Data – A number of locations that contained samples with ERLs also had other samples collected from the same boring. An evaluation of the second samples (those without ERLs) suggested that these samples could be used to show that the sample with an ERL did not represent a data gap. This evaluation was also extended to nearby adjacent borings, located within approximately 10 ft of the boring with an ERL. If analytical results from a soil sample in a nearby soil boring did not exceed ERLs, this result could be used to show the sample with an ERL did not represent a data gap.

4.5.7.2 Elevated Reporting Limits – Individual Evaluation

Between January 2014 through and including February 2014, there were 64 temporary wells installed and sampled. These wells were located adjacent to 47 previously installed temporary wells to provide data to support the conclusion that although there are RLs above potential to leach to groundwater Criteria, the pathway to groundwater is not complete, and therefore the ERLs are not considered a data gap.

4.5.7.3 Elevated Reporting Limits – Data Gap Investigations

After the initial evaluation, the following eight locations remained with unresolved ERLs, which were then addressed through installation of additional temporary wells as outlined below:

RDB

- SBTC0075R008
- SBTC0075R015 (SBTC0075R501)
- SBTC0100R001 (SBTC0100R501)

LDB

- SBTC0075L030
- SBTC0075L501
- SBTC0100C005 (SBTC0100C502)
- SBTC0125L021 (SBTC0125L502)

Soil SPLP results for TCE exceeded the DWC (5 ug/l) in two soil samples (from locations SBTC0075L508 and SBTC0100R501) at concentrations of 10 ug/l and 6.2 ug/l, respectively. However, the groundwater samples from these locations were non-detect for all PNAs and VOCs, including TCE, indicating that TCE is not leaching to groundwater in these locations.

5.0 Reach 3 Results and Exposure Evaluation

This section discusses Reach 3 results and evaluates potential exposure pathways within the Reach. The evaluation of potential exposure pathways was conducted to verify that impacts to the environment do not exceed the Criteria established pursuant to Section 324.20120 (1) of Part 201. One of two conclusions is made for each complete and relevant exposure pathway:

- The results are below the Criteria and are consistent with the generic residential category or
- The results exceed the Criteria and are inconsistent with the generic residential category.

This section also documents the required identification of reasonable and relevant exposure pathways.

5.1.1 Control of Hazardous Substance Sources

Hazardous substance sources related to the Line 6B crude oil release were controlled in the Reach 3 Spill Area by excavating the impacted soils in 2010 and winter of 2011-2012. Excavation activities were performed along Reach 3 of Talmadge Creek as discussed in *Section 4.1* and *Section 4.4*.

While trace amounts of Line 6B crude oil release-related constituents may remain in the soil at previously excavated areas, they are not leachable as evidenced by the lack of SPLP results exceeding Criteria and has not and will not impact groundwater quality. In addition, non aqueous phase liquid (NAPL) has not been observed in any temporary or monitoring well installed as part of the TCRI. NAPL mobility testing has demonstrated that any remaining NAPL, if any, is not mobile.

5.1.2 Groundwater Contamination Risks to Drinking Water Uses

Drinking water is a relevant exposure pathway but it is not complete. No PNAs or VOCs related to the Line 6B crude oil release were detected above Criteria in any representative groundwater samples collected from temporary wells installed in Reach 3 (*Table 7* and *Table 12*).

One potable water well (C002471A) is located within the Reach 3 Spill Area and an additional four potable water wells are located within Reach 3, but are outside the Spill Area boundary.

These five potable water wells have been sampled on an annual basis. No spill-related compounds have been detected in the potable well samples (*Table 1*). Exceedances of Criteria in these samples were limited to metals resulting from naturally occurring, pre-existing groundwater geochemical conditions. *Section 3.4.5* summarizes the metals evaluation, which indicates that the metals are not attributable to the Line 6B crude oil. Therefore, the conditions are consistent with the generic residential category and no action is necessary to address groundwater contamination risks to drinking water uses.

5.1.3 Groundwater Contamination Risks for Indoor Air Hazards

Groundwater volatilization to indoor air is a relevant exposure pathway but it is not complete . Concentrations of all analyzed parameters in groundwater are below the GVIAIC as shown in *Table 7* and *Table 12.* The results are consistent with the generic residential category and no action is necessary to address groundwater contamination risks to indoor air.

5.1.4 Groundwater Contamination Risks of Hazard to Surface Water Resources

Groundwater migration to surface water is a relevant exposure pathway but it is not complete. No exceedances of GSIC by PNAs or VOCs related to the Line 6B crude oil release were detected in any groundwater samples collected from temporary wells installed in Reach 3 as shown in *Table 7* and *Table 12.* As *Section 3.4.5* summarizes, the metals detected in groundwater samples are not attributable to the Line 6B crude oil. The results are consistent with the generic residential category and no action is necessary to address groundwater contamination risks to surface water resources.

5.1.5 Soil Contamination Risks from Direct Contact Exposure

Soil direct contact is a relevant exposure pathway but it is not complete . The concentrations of parameters related to Line 6B crude oil (PNAs and VOCs) in both unsaturated and saturated soil samples collected in the Reach 3 Spill Area are below the DCC as shown in *Table 2, Table 3, Table 4, Table 9, Table 10,* and *Table 13*. In several instances, concentrations of arsenic concentrations did exceed the DCC. However, as *Section 3.4.5* summarizes, arsenic is not attributable to the Line 6B crude oil. The results are consistent with the generic residential category and no action is necessary to address soil contamination risks from direct contact exposure.

5.1.6 Soil Contamination Risks from Ambient Air Inhalation Exposures

Soil volatilization to ambient air is a relevant exposure pathway but it is not complete . Concentrations of all analyzed parameters in soil are well below the VSIC. The results are consistent with the generic residential category and no action is necessary to address soil contamination risks to ambient air.

5.1.7 Soil Contamination Risks from Indoor Air Inhalation Exposures

Soil volatilization to indoor air is a relevant exposure pathway but it is not complete . Concentrations of analyzed parameters related to the Line 6B crude oil release in soil are below the SVIAIC (*Table 2, Table 3, Table 4, Table 9, Table 10,* and *Table 13*) with the exception of chloromethane. Chloromethane exceeded the SVIAIC (2,300 ug/kg) in soil sample SBTC0100R524 (2,500 ug/kg) collected at 0.0 ft to 1 ft (*Table 3*). However, the nearby soil sampling location ESTC0100R146 (less than 5 ft to the northwest) collected at 1.5 ft bgs was non-detect for chloromethane. Chloromethane is a highly volatile gas that was not detected in Line 6B crude oil. In addition, 39% of the chloromethane detects were associated with laboratory blank detections. As a result, it is presumed that chloromethane detections are laboratory artifacts. Additional discussion of this analyte is presented in *Section 4.3.1*. .

The results are consistent with the generic residential category and no action is necessary to address soil contamination risks from indoor air inhalation exposures.

5.1.8 Soil Contamination Risks from Inhalation of Particulates Exposures

Inhalation of soil particulates is a relevant exposure pathway but it is not complete . Concentrations of all analyzed parameters in soil samples from the Reach 3 Spill Area are below PSIC. The results are consistent with the generic residential category and no action is necessary to address soil contamination risks from inhalation of particulates exposures.

5.1.9 Soil Contamination Risk of Injury to Drinking Water Uses of Groundwater

Leaching from soil to drinking water via groundwater is a relevant exposure pathway but it is not complete. Analytical sampling and evaluation has

demonstrated that soil samples with DWPC exceedances will not leach target constituents to groundwater at concentrations that exceed Criteria.

Specifically in Reach 3, this is demonstrated by the analytical results for sample location SBTC0075L508. The soil sample collected at this location reported an analytical result for TCE of 810 ug/kg (above DWPC of 100 ug/kg) and a TCE SPLP result of 10 ug/l (above DWC of 5 ug/l). A subsequent soil sample was collected at this location from the same depth profile one month later. The later sample had an ERL for TCE of < 320 ug/kg and an SPLP of < 1.0 ug/l. A temporary well was installed at this location on the same day as the later soil sampling and a groundwater sample was collected at the water table. The groundwater sample results from location SBTC0075L508, collected nearly three years after the release were non-detect for all PNAs and VOCs including TCE, confirming the second SPLP result and indicating that constituents are not leaching from soil to groundwater at this location.

As a result, the exposure pathway to groundwater is incomplete and the soil exceedances do not pose a threat of groundwater contamination at concentrations exceeding the Criteria. The results are consistent with the generic residential category and no action is necessary to address soil contamination risks to drinking water usage.

5.1.10 Soil Contamination Risk for Groundwater to Pose Risk to Surface Water

Leaching from soil to surface water via groundwater is a relevant exposure pathway but it is not complete . Only one Reach 3 soil sampling location (ESTC0100R154) exhibited a GSIPC exceedance (*Table 9*). Toluene was found in sample ESTC0100R154 (a January 2012 post excavation soil) at a concentration of 8,600 ug/kg at a depth of 2 ft bgs, exceeding the GSIPC of 5,400 ug/kg. As discussed in *Section 4.5.4*, sample location SBTC00100R507 is located immediately adjacent to location ESTC0100R154 and was installed in January 21, 2014. No visual or UV evidence of oil was seen in this boring, which was extended to 3.8 ft bgs. Saturated conditions were noted at a depth of 1.6 ft bgs; therefore no soil sample was collected from the target depth of 2 ft bgs. A temporary well was installed at this location on February 18, 2014, and groundwater was collected from the screened interval of 0.5 to 4.0 ft and analyzed for VOCs. Analytes were below detections limits with the exception of toluene, which was detected in sample location EWTC0075L005 at 1.1 ug/l (*Table 12*). No exceedances of Criteria were detected in this groundwater sample. This result indicates that the ESTC0100R154 soil sample GSIPC exceedance has not resulted in a Criteria exceedance in groundwater.

The results are consistent with the generic residential category and no action is necessary to address soil contamination risk for groundwater to pose a hazard to surface water.

5.1.11 Risk of Contaminated Soils Runoff to Surface Waters

Soil runoff to surface water is a relevant exposure pathway but it is not complete. Surface soil containing exceedances of DCC could potentially erode and be deposited in adjacent surface water. However, as discussed in *Section 5.1.5*, concentrations of parameters related to Line 6B crude oil (PNAs and VOCs) in both unsaturated and saturated soil samples collected in the Reach 3 Spill Area are below the DCC. The results are consistent with the generic residential category and no action is necessary to address contaminated soil runoff to surface water.

5.1.12 Acute Toxic and Physical Hazard Risks

Acute toxic hazards are generally related to inhalation exposures, explosions, or fire. All results from Reach 3 sample analyses are below the PSIC. Flammable or explosive chemicals have not been detected at levels that would pose a risk of fire or explosion. There are no acute or physical hazard risks within the Reach 3 Spill Area.

5.1.13 Aesthetic Impacts

Aesthetic impacts are based on a subjective evaluation of the effects of a physical or chemical characteristic of a constituent that is specifically not detrimental to human health (i.e., does not exceed established risk-based criteria). Aesthetic impacts are those characteristics of a constituent which are observable (generally through sight or smell) and that may be aesthetically objectionable to an individual who encounters them.

Enbridge performed an aesthetic impact assessment of observed remaining Line 6B crude oil impact on surface water, groundwater, sediment in the overbank areas, and soil within Reach 3. This assessment was conducted in accordance with current Part 201 rules and MDEQ-published guidance documents, which provide very limited guidance on what constitutes an aesthetic impact and more specifically what aesthetic impacts would require further action. To supplement this limited guidance, Enbridge utilized the MDEQ website to track instances where aesthetic notifications have been implemented on other projects and the specific conditions under which those notifications were required. In addition, Enbridge also reviewed and considered the MDEQ's *Technical Review Comments - Aesthetic Concerns on the Remedial Investigation Report for Reach 1*, issued on May 14, 2014 (MDEQ, 2014a) and the MDEQ's *Technical Review Comments* within the *Notice of Insufficient Information in*

Reach 5 No Further Action Report, issued on August 22, 2014 (MDEQ, 2014b). Finally, Enbridge contacted numerous MDEQ personnel from districts throughout Michigan seeking examples and guidance on the MDEQ position on aesthetics (especially regarding soils) and used that information in the aesthetic evaluation for this site.

Based on review of these materials, Enbridge understands the MDEQ Kalamazoo District considers the following conditions as potentially actionable aesthetic impacts relevant to the Line 6B crude oil release:

- Exceedance of MDEQ groundwater aesthetic Criteria:
- Sheen observed within a soil core, on borehole water, or on purge water;
- Petroleum odors observed within soils or in purge water; and,
- Visible oil.

To fully evaluate these potential aesthetic conditions within the Reach 3 Spill Area, Enbridge compiled a list of the occurrences of these aesthetic conditions from the field forms that have been completed during the course of this project, including: soil boring logs, well construction reports, groundwater sampling logs, and field notes. *Table 14* presents a tabulated summary of these aesthetic observations.

An analysis of the aesthetic observations presented in *Table 14* is presented below in the context of the guidance documents and MDEQ comments. The findings of the aesthetics evaluation for the Reach 3 Spill Area remaining Line 6B crude oil impacts are presented by media type (i.e., surface water, groundwater, and soil).

5.1.13.1 Surface Water Aesthetic Evaluation

Visual inspections for the presence of sheen on surface water in overbank depressions or pools were completed at 17 pre-determined locations within Reach 3 where previous observations had identified sheen. During the data gap evaluation in April of 2014, these locations were revisited and visually inspected for surficial impacts to evaluate current site conditions as discussed in *Section 4.5.1*. There were no surficial aesthetic observations noted at any of these locations during the 2014 data gap assessment. Based on this evaluation, Enbridge has concluded that there are no surface water aesthetic issues within Reach 3.

5.1.13.2 Groundwater Aesthetic Evaluation

The groundwater aesthetic assessment was conducted primarily by comparing groundwater analytical results to aesthetics-based groundwater Criteria. This comparison has shown that no groundwater samples collected from Reach 3 contained constituents attributable to Line 6B crude oil at concentrations above the aesthetic Criteria.

Sheen was observed on borehole water and/or temporary well purge water at several locations; however, Enbridge does not consider sheen observations on borehole water and/or temporary well purge water to be an actionable aesthetic impact and additional evaluation or action is not required.

Petroleum odors in groundwater were not identified within Reach 3. Further, Enbridge does not consider petroleum odor in groundwater to be an actionable aesthetic impact, except in the case of groundwater that may be used for drinking water purposes. Due to the proximity of Talmadge Creek, groundwater within the Reach 3 Spill Area would not be used for drinking water purposes. No petroleum odors were identified in groundwater in Reach 3 and additional evaluation or action is not required.

Based on this evaluation, no actionable aesthetic impacts are present with regard to groundwater within the Reach 3 Spill Area.

5.1.13.3 Soil Aesthetic Evaluation

Enbridge does not consider the observations of sheen or odor in subsurface soil samples or boreholes to represent an actionable aesthetic impact. The limited, sporadic observations of sheens or odors only occur when intrusive activities (e.g., drilling, excavation, etc.) are conducted below the ground surface. Given the discrete and isolated locations of these aesthetic issues within the flood plain, any subsurface sheen and odor are unlikely to reach the ground surface, and would not be observable and/or likely to be considered as objectionable from an individual's perspective.

Following extensive remedial activities conducted within Reach 3, visible oil was not identified.

Based on this evaluation, no actionable aesthetic impacts are present with regard to soil within the Reach 3 Spill Area.

5.1.13.4 Aesthetics Conclusion

The instances where potential aesthetic impacts have been observed in the Reach 3 Spill Area have dramatically decreased as a result of ongoing remedial efforts and natural degradation. Based on a thorough and comprehensive review of potential aesthetic impact observations in Reach 3, Enbridge has not identified any aesthetic impacts that would require additional evaluation or action. If the MDEQ believes that actionable aesthetic impacts remain, Enbridge requests that the MDEQ provide documentation of relevant rules, regulations, or legal precedents that support the claim that actionable aesthetic impacts (requiring remediation or a deed notification) remain.

5.1.14Terrestrial Evaluation

The R5 ESL soil comparison identified potential terrestrial ecological risks at the following locations:

- Soil sample ESTC0075R134- naphthalene detection at a concentration of 350 ug/kg, which exceeded the soil R5 ESL of 99.4 ug/kg, and
- Soil sample ESTC0100R154- toluene detection at a concentration of 8,600 ug/kg, which exceeded the soil R5 ESL of 5,450 ug/kg.

All other analytical results were below corresponding R5 ESLs for Line 6B crude oil parameters.

The R5 ESLs for naphthalene and toluene are based on the masked shrew receptor, which is a small predator of soil invertebrates. The two exceedance locations are discrete and isolated from each other, and do not indicate the presence of “hot spots.” Masked shrews have a typical home range of approximately 1 acre (U.S. EPA, 1993). This home range is much larger than the area represented by these two isolated soil samples, therefore the shrew population would be exposed to significantly lower average concentrations of these constituents.

These two isolated R5 ESLs exceedances do not pose significant ecological risks due to their isolated nature, relatively low magnitude, and infrequent occurrence; and because the average overall exposure of the masked shrew receptor would be to concentrations significantly lower than those detected at these discrete locations. Neither of these chemicals is bio-accumulative. In addition, both naphthalene and toluene biodegrade readily and will not persist in the environment.

Enbridge has completed the evaluation of potential terrestrial risks, and based on this evaluation, no terrestrial risks are present with regard to soil within the Reach 3 Spill Area.

5.1.15 Other Hazardous Substance Risks at or Posed by the Property

There are no other known hazardous substance risks at or posed by the conditions in this Reach.

5.2 Proposed and Completed Remedial Actions

Remedial actions were completed in the Reach 3 Spill Area of Talmadge Creek through excavation activities in 2010, 2011, and 2012 as discussed in *Section 4*. No additional remedial activities are proposed for the Reach 3 Spill Area.

6.0 Summary and Conclusions

This RI Report documents the response, remediation, and characterization work conducted within Reach 3. These efforts were completed to address impacts from the July 2010 crude oil release from the Enbridge Line 6B pipeline in Marshall, Michigan. Reach 3, which consists of the segment of Talmadge Creek from MP 0.50 to I-69 (MP 1.25), has undergone extensive response and remediation activities as documented in *Section 2* and *Section 3* of this report, as well as a thorough characterization of existing conditions as presented in *Section 4* and *Section* 5 of this report.

6.1 Summary of Remedial Activities and Investigations

The following subsections provide a brief review of response, remediation, and characterization work conducted within Reach 3.

6.1.1 Talmadge Creek Response Excavation (2010)

In the fall of 2010, emergency response excavations were conducted and areas adjacent to Talmadge Creek that exhibited visible evidence of Line 6B crude oil were excavated (excluding the streambed). Upon completion of the excavation, U.S. EPA provided clearance. The *Source Contamination Removal and Verification Summary Report Talmadge Creek: Section 1 to Section 10* (Enbridge, 2010f) found that no additional cleanup was necessary to fulfill the U.S. EPA Order. Review of the analytical results from the 2010 post-excavation assessment soil sampling reveals that none of the soil samples collected exhibited Criteria exceedances. Decommissioning within the Reach 3 Spill Area included the collection and analyses of soil samples. The analytical results from the decommissioning samples indicate that no exceedances of Criteria by spill-related compounds were detected.

6.1.2 2011 Shoreline and Overbank Re-assessment Technique on Talmadge Creek

At the time of the 2011 SORT Reassessment, the LDB and RDB within Reach 3 generally consisted of a re-engineered low vegetated bank with ECB covering the overbank and coir logs at the shoreline. SORT observations were reviewed and subsequently approved by START, MDEQ, and Enbridge personnel. No recommendations for SORT follow-up activities were documented and therefore no follow-up assessment was conducted on Reach 3 during the 2012 SORT Reassessment activities.

6.1.3 Talmadge Creek Remedial Investigation

The 2011 TCRI was conducted to define the nature and extent of remaining impacts to the Reach 3 Spill Area, and identify areas where additional cleanup may be required. Review of the analytical results from the TCRI soil sampling revealed that chloromethane and TCE were detected above Criteria; however, no exceedances by VOCs associated with Line 6B crude oil were detected.

Chloromethane is a highly volatile gas that was not detected in Line 6B crude oil. In addition, 39% of the chloromethane detects were associated with laboratory blank detections. As a result, it is presumed that chloromethane detections are laboratory artifacts.

Although soil SPLP results for TCE exceeded the DWC (5 ug/kg) in two soil samples (SBTC0075L508 and SBTC0100R501) at concentrations of 10 ug/l and 6.2 ug/l, respectively, the groundwater samples from these locations were non-detect for all PNAs and VOCs. Thus indicating that TCE is not leaching to groundwater in these locations. TCE was not detected in Line 6B crude oil; however, it may or may not be related to response activities completed in the Spill Area. Notably, the location of this TCE detection is adjacent to a utility corridor, which makes it possible that the source is related to other historic work completed in the area. Regardless, further investigation into the low level detection of TCE has demonstrated no potential risk to human health.

Sediment samples were collected from within the Reach 3 channel of Talmadge Creek to delineate the vertical and lateral extent of remaining Line 6B crude oil within the sediment. Comparison of the analytical results from these sediment samples to Criteria indicates there were no exceedances in any of the sediment samples.

Also during the TCRI, groundwater samples were collected from temporary wells. Comparisons of these groundwater analytical results to Criteria indicate there were no exceedances by any VOCs or PNAs in any of the samples.

Surface water samples were collected during the TCRI, from a wetland area situated north of Talmadge Creek between MP 0.75 - MP 1.00. A comparison of surface water analytical results to Criteria shows there were no exceedances by VOCs or PNAs in these samples.

6.1.4 Talmadge Creek Excavation (2011–2012)

The excavation activities that took place from November 2011 through and including early March 2012, included excavation of streambed sediments, several selected overbank areas, and portions of the adjacent wetland. Excavation activities were conducted until no Line 6B crude oil was observed. The excavation was backfilled with clean fill and restored following the excavation.

In the post-excavation soil samples that were collected, chloromethane and toluene were detected above Criteria in two separate 2011-2012 soil samples. Chloromethane is a highly volatile gas with a boiling point of approximately -20°C (-4°F), therefore, any releases to surface soil would be expected to immediately evaporate. Chloromethane is not associated with Line 6B crude oil and detections are likely laboratory artifacts. Toluene was found in sample ESTC0100R154 at a concentration of 8,600 ug/kg, exceeding the GSIPC of 5,400 ug/kg. As discussed in *Section 4.5.4*, follow up sample location SBTC00100R507 is located immediately adjacent to location ESTC0100R154. A temporary well was installed at SBTC00100R507and groundwater was collected and analyzed for VOCs. Analytes were below detections limits with the exception of toluene, which was detected in sample location EWTC0075L005 at 1.1 ug/l (*Table 12*). No exceedances of Criteria were detected in this groundwater sample. This result indicates that the ESTC0100R154 soil sample GSIPC exceedance has not resulted in a Criteria exceedance in groundwater.

A comparison of the groundwater analytical results from samples that were collected during the 2011 excavation activities to Criteria shows there were no exceedances of any VOCs or PNAs in these groundwater samples.

In January 2013, decommissioning activities within Reach 3 included the collection of soil samples from support areas utilized during the 2011-2012 excavation activities. Analytical results indicate that there were no exceedances of Criteria by site-related compounds in the decommissioning soil samples.

6.2 Conclusions

As described in the following sections, no human health or terrestrial risks or actionable aesthetic conditions associated with Line 6B crude oil have been identified in the Reach 3 Spill Area.

6.2.1 Soil

TCE exceeded DWPC (100 ug/kg) in sample SBTC0075L508 at a concentration of 810 ug/kg (*Table 3*). The SPLP soil samples from SBTC0100R501 and SBTC0075L508 (*Table 5*) both exceeded the Part 201 DWC of 5 ug/l for TCE (6.2 ug/l and 10 ug/l, respectively). However, the groundwater samples collected at each of these locations were non-detect for PNAs and VOCs including TCE (*Table 7* and *Table 12*), indicating that constituents are not leaching from soil to groundwater at this location.

Chloromethane exceeded the SVIAIC (2,300 ug/kg) in soil sample SBTC0100R524 (2,500 ug/kg) collected at 0.0 ft to 1 ft bgs (*Table 3)*. However, chloromethane is a highly volatile gas that was not detected in Line 6B crude oil. In addition, 39% of the chloromethane detects were associated with laboratory blank detections. As a result, it is presumed that chloromethane detections are laboratory artifacts. .

Toluene was found in sample ESTC0100R154 at a concentration of 8,600 ug/kg, exceeding the GSIPC of 5,400 ug/kg (*Table 9*). However, groundwater analyzed from the immediately adjacent SBTC00100R507 indicates that the ESTC0100R154 soil sample GSIPC exceedance has not resulted in a Criteria exceedance in groundwater.

Sufficient data has been collected, analyzed, and evaluated to support the position that no further action is necessary to address human health risks related to soil at Reach 3.

Enbridge completed an evaluation of potential terrestrial risks by comparing all soil analytical results to the R5 ESL screening levels. This evaluation identified two locations where soil concentrations exceeded the R5 ESL screening levels, indicating that there is the potential for terrestrial risks at these locations as detailed in *Section 15.1.14*. Based on this evaluation at these two locations, no terrestrial risks are present with regard to soil within the Reach 3 Spill Area.

Enbridge also completed a thorough evaluation of potential aesthetic impacts to soil as detailed in *Section 5.1.13*. Based on this evaluation, no actionable aesthetic impacts are present with regard to soil within the Reach 3 Spill Area.

6.2.2 Sediment

Sediment samples were collected as part of the SOTF in 2010, during October 2011 as part of the TCRI, and in early 2014 to address data gaps. *Figure 9* depicts the sample locations.

Table 6 presents a tabulated summary of the analytical results from sediment samples collected from Talmadge Creek.

A comparison of the results in *Table 6* to Criteria shows that there were no exceedances of DCC in any of the sediment samples. Note that the majority of these sediment sample locations were excavated during the extensive excavation activities that took place from November 2011 through and including early March 2012, which removed streambed sediments; and reconstructed and restored the streambed.

Enbridge has completed a thorough evaluation of potential terrestrial risks by comparing all sediment analytical results to the R5 ESL sediment screening levels. No exceedances were identified within the Reach 3 Spill Area.

Enbridge also completed a thorough evaluation of potential aesthetic impacts to sediment as detailed in *Section 5.1.13*. Based on this evaluation, no actionable aesthetic impacts are present with regard to sediment within the Reach 3 Spill Area.

Sufficient data has been collected, analyzed, and evaluated to support the position that no further action is necessary to address human health or terrestrial risks, or potential aesthetic impacts related to sediment in the Reach 3 Spill Area.

6.2.3 Groundwater

The analytical results from groundwater samples collected in the Reach 3 Spill Area during the TCRI and post-excavation activities have been compared to human health Criteria. There were no exceedances of any VOCs or PNAs in any of the groundwater samples (*Table 7* and *Table 12*).

Enbridge also completed a thorough evaluation of potential aesthetic impacts to groundwater as detailed in *Section 5.1.13*. Based on this evaluation, no actionable aesthetic impacts are present with regard to groundwater within the Reach 3 Spill Area.

Sufficient data has been collected, analyzed, and evaluated to support the position that no further action is necessary to address human health or terrestrial risks, or potential aesthetic impacts related to groundwater in the Reach 3 Spill Area.

6.2.4 Surface Water

The analytical results from surface water samples collected from a wetland area situated north of Talmadge Creek between MP 0.75 - MP 1.00 (*Table 8*) were compared to human health Criteria. There were no exceedances by any VOCs or PNAs in any of the samples.

Enbridge also completed a thorough evaluation of potential aesthetic impacts to groundwater as detailed in *Section 5.1.13*. Based on this evaluation, no actionable aesthetic impacts are present with regard to surface water within the Reach 3 Spill Area.

Sufficient data has been collected, analyzed and evaluated to support the position that no further action is necessary to address human health or terrestrial risks, or potential aesthetic impacts related to surface water in the Reach 3 Spill Area.

7.0 References

Apple and Reeves, 2007. Apple, Beth A. and Howard W. Reeves; Summary of Hydrogeologic Conditions by County for the State of Michigan, U.S. Geological Survey Open-File Report 2007-1236, 87 pp. September 21, 2007.

ASTM, 1985. American Society for Testing and Materials; *Standard Practice for Classification of Soils for Engineering Purposes: Annual Book of ASTM Standards*, D 2487-83, 04.08, pp. 395–408. 1985.

Bent, 1971. Bent, P.C., 1971. Influence of Surface Glacial Deposits on Streamflow Characteristics of Michigan Streams. U.S. Geological Survey, Lansing, MI.

Enbridge, 2010a. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Work Plan Enbridge Marshall Pipeline Release,* dated July 29, 2010.

Enbridge, 2010b. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Source Area Response Plan*, dated August 19, 2010.

Enbridge, 2010c. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Evaluation of Potential Impact of Released Oil on Groundwater used for Drinking Water (Hydrogeologic Evaluation Report)*, dated October 30, 2010.

Enbridge, 2010d. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Post-Response Shallow Soil Assessment Work Plan,* dated September 4, 2010.

Enbridge, 2010e. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Supplemental Source Area Response Plan*, dated October 17, 2010.

Enbridge, 2010f. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Source Contamination Removal and Verification Summary Report Talmadge Creek: Section 1 to Section 10*, dated September 26, 2010.

Enbridge, 2011a. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Conceptual Site Model*, dated July 8, 2011.

Enbridge, 2011b. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Remedial Investigation Work Plan for Talmadge Creek from MP 0.50 to 2.25*, dated September 15, 2011.

Enbridge, 2011c. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Talmadge Creek Excavation Work Plan MP 0.50 – MP 1.00,* dated December 7, 2011.

Enbridge, 2011d. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Quality Assurance Project Plan (QAPP)*, dated August 19, 2011.

Enbridge, 2011e. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Sampling and Analysis Plan (SAP)*, dated August 30, 2011.

Enbridge, 2011f. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Talmadge Creek Remedial Investigation Work Plan MP 0.50 – 2.25, Supplement: Additional Investigation of Impacted Areas*, dated December 28, 2011.

Enbridge, 2011g. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Analytical Sampling Approach at Excavation Sites Memorandum,* dated December 21, 2011.

Enbridge, 2012a. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Talmadge Creek Excavation Work Plan MP 1.00 – MP 2.25*, dated February 16, 2012.

Enbridge, 2012b. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release Marshall, Michigan; *Analytical Quality Assurance Plan, Version 2.3*, dated December 21, 2012.

Enbridge, 2013a. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Conceptual Site Model – 2013*, dated April 25, 2013.

Enbridge, 2013b. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Supplement to the Response Plan for Downstream Impacted Areas commonly referred to as the "Quantification of Submerged Oil Report"*, dated March 21, 2013.

Enbridge, 2013c. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Report of Findings for Hydrocarbon Fingerprint Evaluation in Overbank Soil*, dated May 7, 2013.

Enbridge, 2013d . Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *SAP Attachment B Drinking Water Well Supplement to the Sampling and Analysis Plan*, dated April 10, 2013.

Enbridge, 2013e. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *2013 Waste Treatment, Transportation, and Disposal Plan*, dated September 16, 2013.

Enbridge, 2013f. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Addendum to the 2013 Waste Treatment, Transportation, and Disposal Plan*, dated November 12, 2013.

Enbridge, 2013g. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Draft No Further Action Report Reach 3 - MP 0.50 to MP 1.00*, dated August 9, 2013.

Enbridge, 2014a. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Conceptual Site Model – 2014*, dated July 24, 2014.

Enbridge, 2014b. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *White Paper: Evaluation of Line 6B Crude Oil PNA and VOC Related Risk to Groundwater Quality*, dated July 24, 2014.

Enbridge, 2014c. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *White Paper: Evaluation of Metals in Soil and Groundwater*, dated June 4, 2014.

Enbridge, 2014d. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Reach 1 Remedial Investigation Report*, dated February 28, 2014.

Enbridge, 2014e. Enbridge Energy, Limited Partnership Line 6B MP 608 Pipeline Release, Marshall, Michigan; *Reach 5 No Further Action Report*, dated March 28, 2014.

Harrell, et al., 1991. Harrell, J.A., Hatfield, C.B., and Gunn, G.R; *Early sedimentary evolution of the Michigan Basin; Mississippian System of the Michigan basin; Stratigraphy, sedimentology, and economic geology.* Geological Society of America Special Paper 256, pp. 203 – 219. June 3, 1991.

MDEQ, 2002. "Michigan Department of Environmental Quality; Sampling Strategies and Statistics Training Materials for Part 201 Cleanup Criteria." August 2002.

MDEQ, 2007. "Michigan Department of Environmental Quality; Remediation and Redevelopment Division Operational Memorandum No. 1, - Attachment 7: Part 201 Generic Soil Inhalation Criteria for Ambient Air and Part 213 Tier I Soil Inhalation Risk-Based Screening levels for ambient air".

MDEQ, 2010. "Michigan Department of Environmental Quality; Administrative Consent Order and Partial Settlement Agreement entered In the Matter of Enbridge Energy Partners, L.P., and Enbridge Energy, Limited Partnership, proceedings under the Michigan Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, MCL 324.101 et seq." November 1, 2010.

MDEQ, 2014a. Michigan Department of Environmental Quality*; Technical Review Comments - Aesthetic Concerns on the Remedial Investigation Report for Reach 1*. May 14, 2014.

MDEQ 2014b. Michigan Department of Environmental Quality; *Technical Review Comments* within the *Notice of Insufficient Information in Reach 5 No Further Action Report*. August 22, 2014.

Midwest Geosciences Group, 2006. *Field Guide for Soil and Stratigraphic Analysis v.2*. 2006.

Munsell, 2009. *Munsell Soil Color Chart System*, Munsell Color, Grand Rapids, Michigan. 2009.

NOAA, 2000. National Oceanic and Atmospheric Administration; *Shoreline Assessment Manual*. Third Edition, HAZMAT Report 2000-1. Seattle: Office of Response and Restoration, National Oceanic and Atmospheric Administration. 54 pp. August, 2000.

Rachol et al., 2005. C.M. Rachol, F.A. Fitzpatrick, and T. Rossi. 2005. *Historical and Simulated Changes in Channel Characteristics of the Kalamazoo River, Plainwell to Otsego, Michigan*. Scientific Investigations Report 2005-5044, U.S. Department of Interior, USGS.

U.S. EPA, 1993. United States Environmental Protection Agency; *Wildlife Exposure Factors Handbook.* U.S. Environmental Protection Agency, Washington D.C., EPA/600/R-93/187.

U.S. EPA, 2003. *"U.S. EPA, Region 5, RCRA Ecological Screening Levels"*, August 22, 2003. http://www.epa.gov/Region5/waste/cars/pdfs/ecological-screening-levels-200308.pdf

U.S. EPA, 2010. "United States Environmental Protection Agency; *Removal Administrative Order Under Section 311(c) of the Clean Water Act*, issued on July 27, 2010 to Enbridge Energy Partners, L.P., Docket Number: CWA 1321-5-10-001 as modified by Paragraph 6 of the Supplement to Order for Compliance Under Section 311(c) of the Clean Water Act, issued by the U.S. EPA Region 5 on September 23, 2010 to Enbridge Energy Partners, L.P. *et al*., Respondents, Docket No: CWA 1321-5-10-001." September 23, 2010.

U.S. EPA, 2011. "United States Environmental Protection Agency; Notice to Enbridge dated March 7, 2011. The Notice directs Enbridge to perform assessment activities pursuant to the Administrative Order issued by the U.S. EPA on July 27, 2010 and a Supplement to the Order for Compliance under Section 311(c) of the CWA issued ("Supplement") by the U.S. EPA on September 23, 2010." March 7, 2011.

Wesley, 2005. J.K. Wesley. Kalamazoo River Assessment. State of Michigan, Department of Natural Resources, Fisheries Division Special Report Number 35.

WMU, 1981. Department of Geology, College of Arts and Sciences, Western Michigan University, Hydrogeologic Atlas of Michigan.

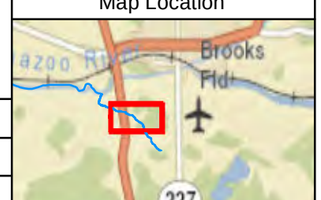
Figures

1

ENBRIDGE

Drawn:	NS	9/3/2014
Approved:	PL	9/3/2014
Project #:	60313732	

Map Location



Legend

- Zoned Agricultural
- Decommissioning Activities
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline

N

0 175 350 700

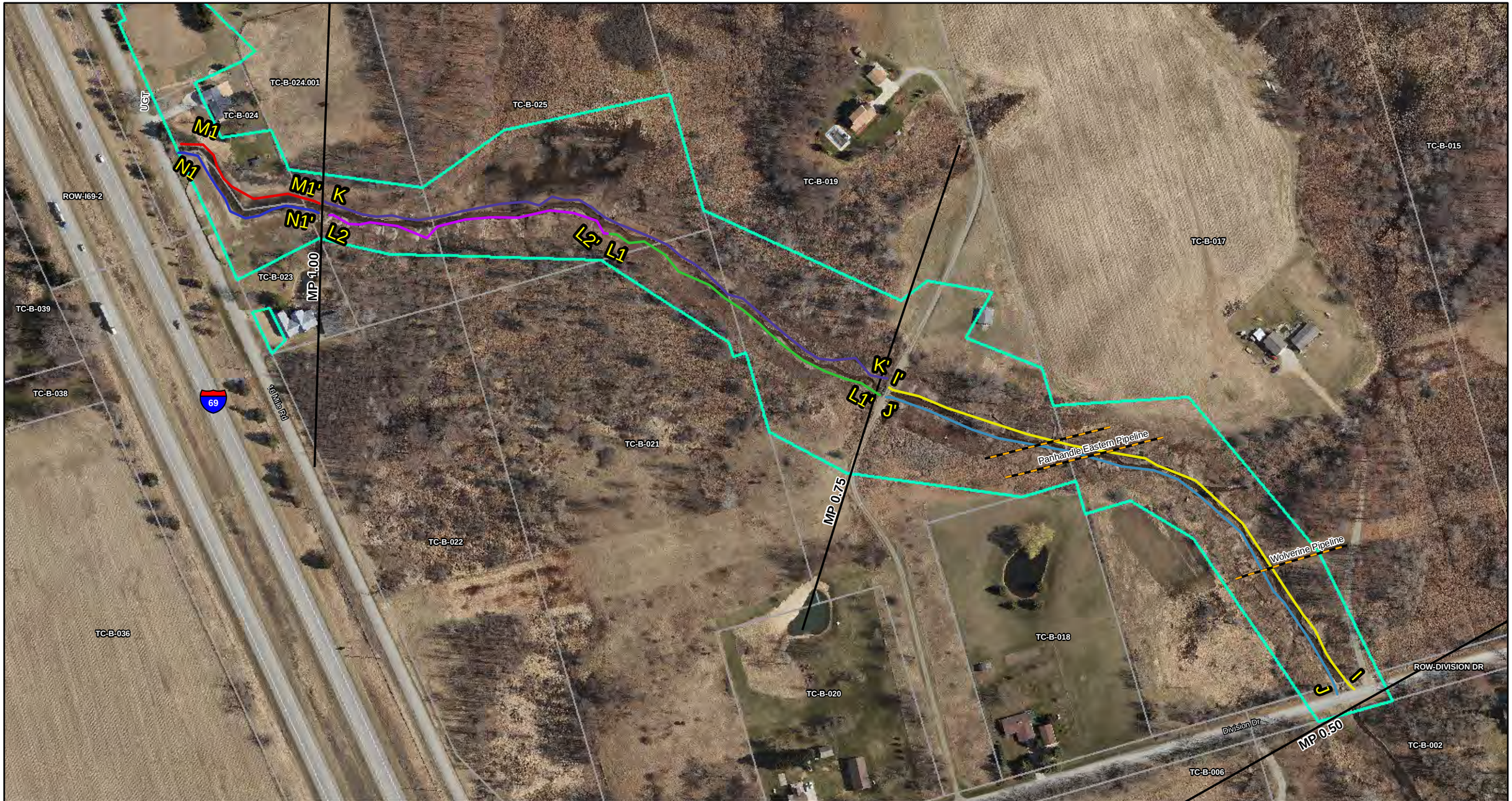
Scale in Feet

FIGURE 1
REACH 3
SITE LOCATION

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_01_Reach_3_Site_Location.mxd

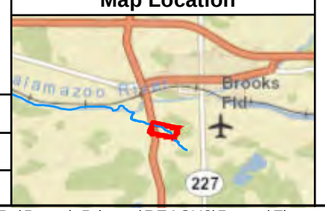
Aerial Photography Date: April 2011



ENBRIDGE

Drawn:	NS	9/22/2014
Approved:	PL	9/22/2014
Project #:	60313732	

Map Location



Legend

- Cross Section I-I'
- Cross Section J-J'
- Cross Section K-K'
- Cross Section L1-L1'
- Cross Section L2-L2'
- Cross Section M1-M1'
- Cross Section N1-N1'
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline

N

0 100 200 400

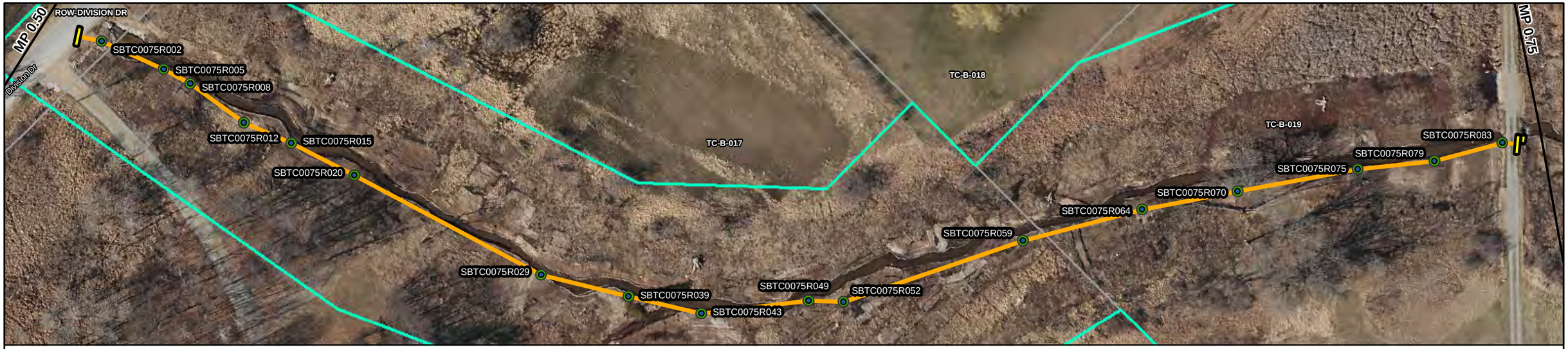
Scale in Feet

FIGURE 2
REACH 3
GEOLOGIC CROSS SECTION OVERVIEW
SHEET 1 OF 8

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_02_Reach_3_Geology_XS_Overview_Sheet_1.mxd

Aerial Photography Date: April 2011

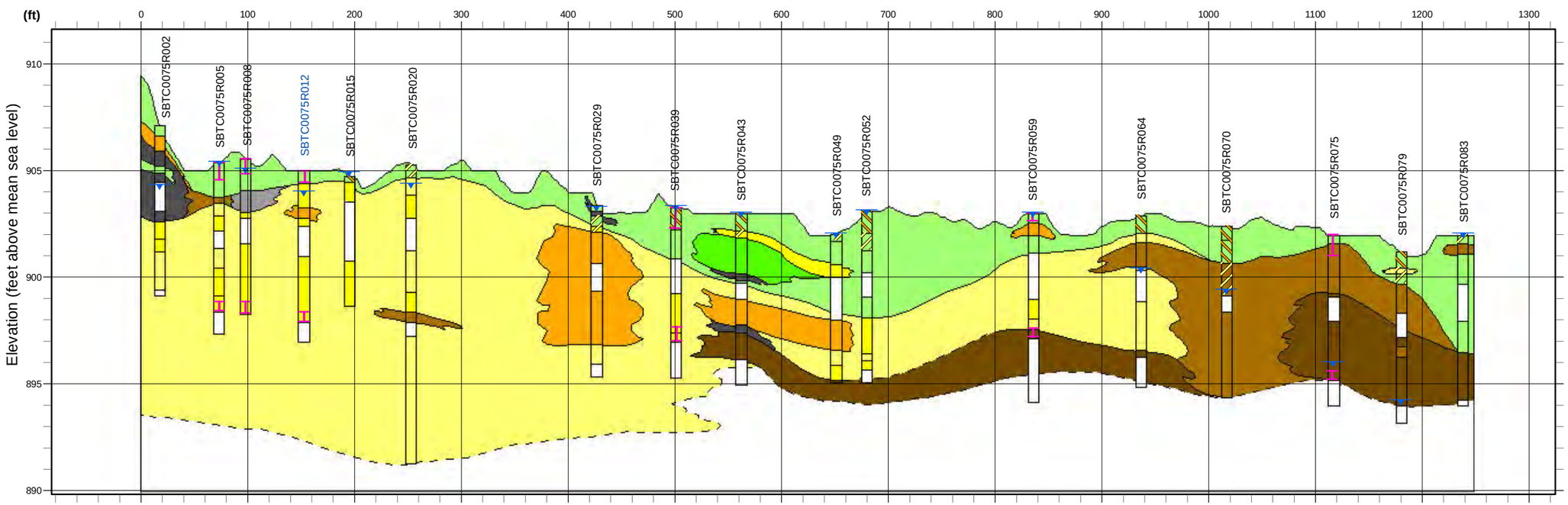


Cross Section I-I'

Vertical Exaggeration: 20x

South MP 0.50 I

North MP 0.75 I'



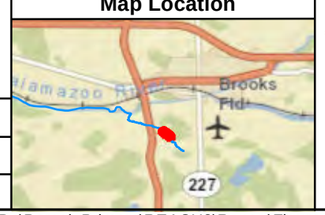
USCS

- No Recovery
- Peat
- Organic Soils
- Clay Soils
- Clay Soil Subgroups
- Silt Soils
- Silt Soil Subgroups
- Sand Soils
- Sand Soil Subgroups
- Gravel Soils
- Gravel Soil Subgroups
- Bedrock

ENBRIDGE

Drawn:	NS	9/22/2014
Approved:	PL	9/22/2014
Project #:	60313732	

Map Location



Overview Legend

- Cross Section I-I'
- Cores
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments

Cross Section Legend

- Sample Interval
- Water Level

Observations

- Oil Under Visible Light
- Sheen Under Visible Light
- Fluoresced Oil
- Trace Fluorescence

SBTC0000R000 **Temporary Well Location**

Note: Soil borings with no water levels shown are due to no water present in bore hole.

N

0 40 80 160

Scale in Feet

FIGURE 2
REACH 3
GEOLOGIC CROSS SECTION I-I'
SHEET 2 OF 8

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_02_Reach_3_Geology_XS_I_Sheet_2.mxd

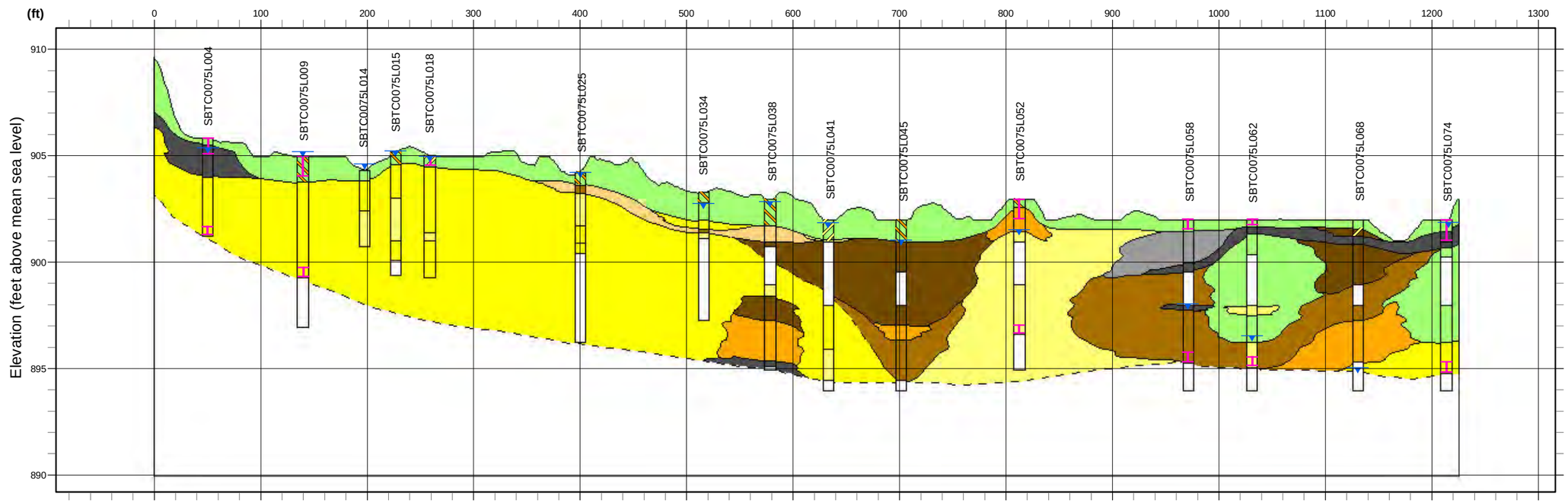
Aerial Photography Date: April 2011

Cross Section J-J'

Vertical Exaggeration: 20x

South MP 0.50
J

North MP 0.75
J'



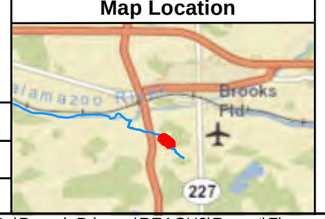
USCS

- No Recovery
- Peat
- Organic Soils
- Clay Soils
- Clay Soil Subgroups
- Silt Soils
- Silt Soil Subgroups
- Sand Soils
- Sand Soil Subgroups
- Gravel Soils
- Gravel Soil Subgroups
- Bedrock

ENBRIDGE

Drawn:	NS	9/22/2014
Approved:	PL	9/22/2014
Project #:	60313732	

Map Location



Overview Legend

- Cross Section J-J'
- Cores
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments

Cross Section Legend

- Sample Interval
- Water Level

Observations

- Oil Under Visible Light
- Sheen Under Visible Light
- Fluoresced Oil
- Trace Fluorescence

SBTC0000R000 **Temporary Well Location**

Note: Soil borings with no water levels shown are due to no water present in bore hole.

N

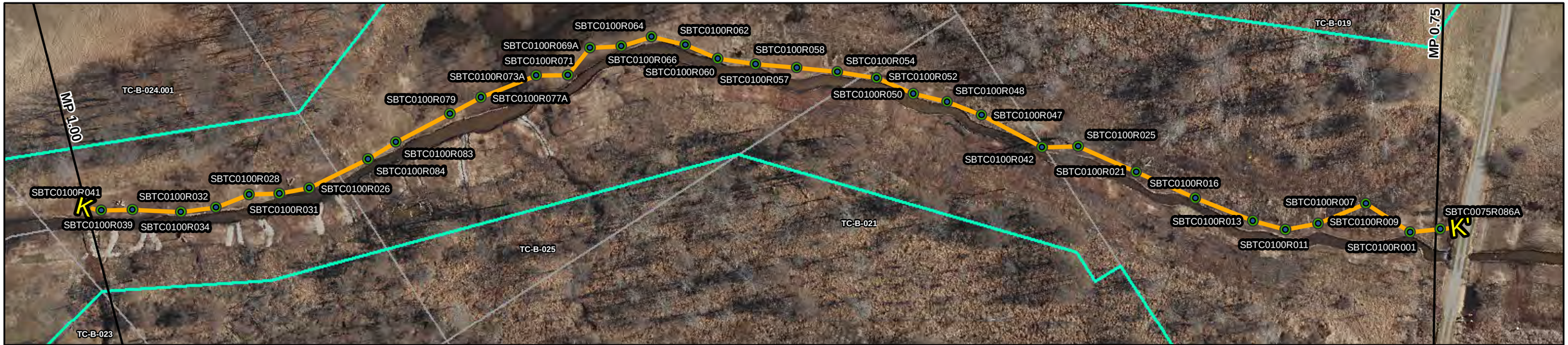
0 40 80 160
Scale in Feet

FIGURE 2
REACH 3
GEOLOGIC CROSS SECTION J-J'
SHEET 3 OF 8

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_02_Reach_3_Geology_XS_J_Sheet_3.mxd

Aerial Photography Date: April 2011

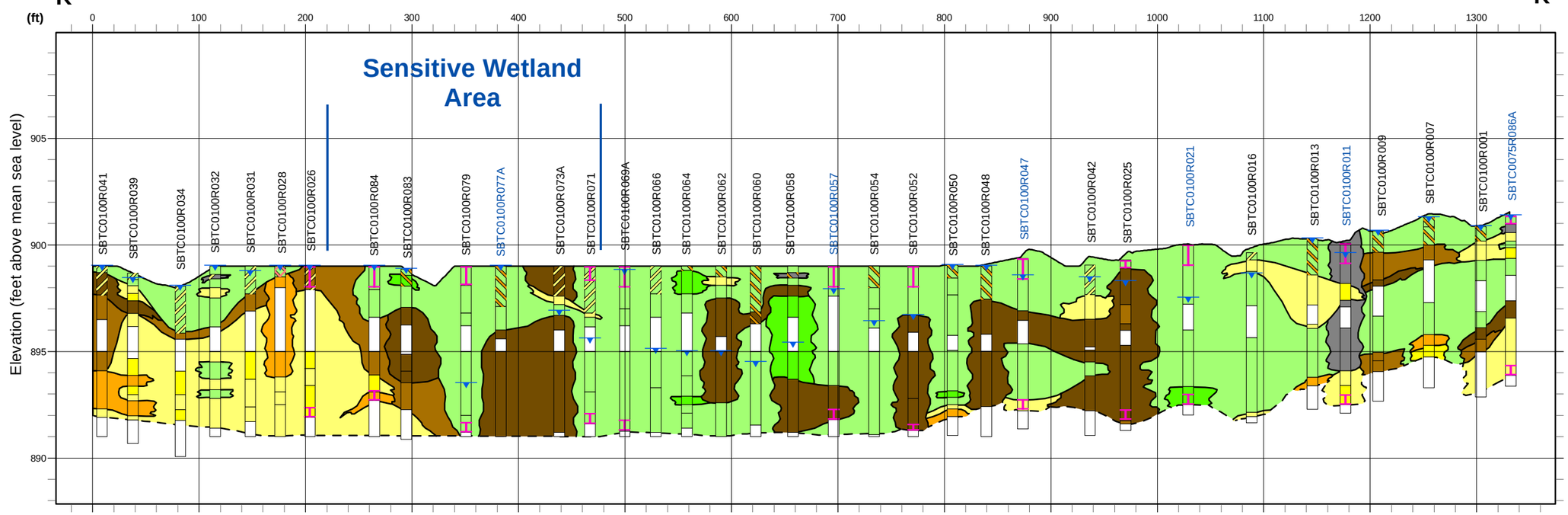


Cross Section K-K'

Vertical Exaggeration: 20x

North MP 1.00
K

South MP 0.75
K'



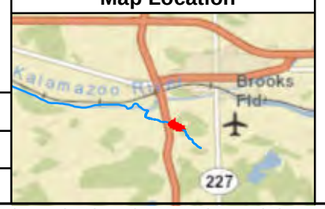
Soil Type

- No Recovery
- Clay
- Silt
- Silt Subclass
- Gravel
- Sand
- Sand Subclass
- Peat
- Organic

ENBRIDGE

Drawn:	NS	9/22/2014
Approved:	PL	9/22/2014
Project #:	60313732	

Map Location



Overview Legend

- Cross Section K-K'
- Cross Section Cores
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments

Cross Section Legend

- Sample Interval
- Water Level

Observations

- Oil Under Visible Light
- Sheen Under Visible Light
- Fluoresced Oil
- Trace Fluorescence

SBTC0000R000 **Temporary Well Location**

Note: Soil borings with no water levels shown are due to no water present in bore hole.

N

0 45 90 180
Scale in Feet

FIGURE 2
REACH 3
GEOLOGIC CROSS SECTION K-K'
SHEET 4 OF 8

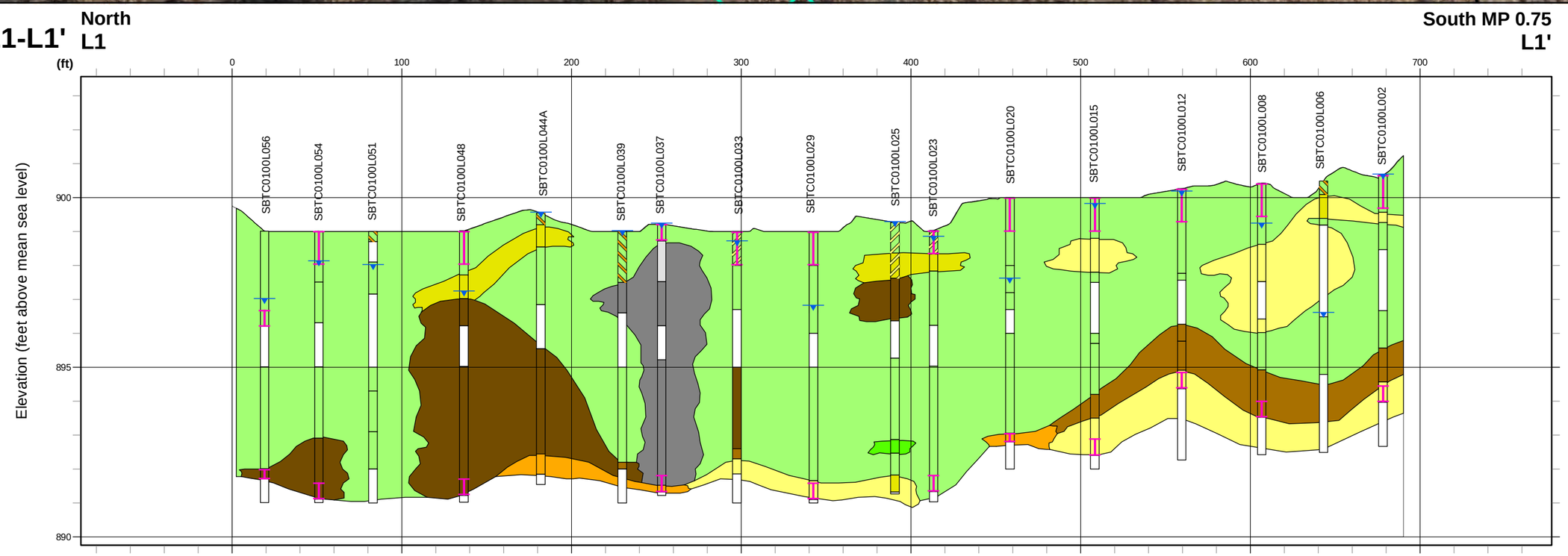
ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_02_Reach_3_Geology_XS_K_Sheet_4.mxd

Aerial Photography Date: April 2011

Cross Section L1-L1'

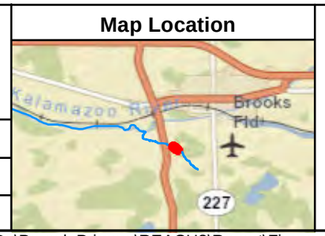
Vertical Exaggeration: 20x



ENBRIDGE

Drawn:	NS	9/22/2014
Approved:	PL	9/22/2014
Project #:	60313732	

Map Location



Overview Legend

- Cross Section L1-L1'
- Cores
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments

Cross Section Legend

- Sample Interval
- Water Level

Observations

- Oil Under Visible Light
- Sheen Under Visible Light
- Fluoresced Oil
- Trace Fluorescence

SBTC0000R000 **Temporary Well Location**

Note: Soil borings with no water levels shown are due to no water present in bore hole.

N

0 25 50 100
Scale in Feet

FIGURE 2
REACH 3
GEOLOGIC CROSS SECTION L1-L1'
SHEET 5 OF 8

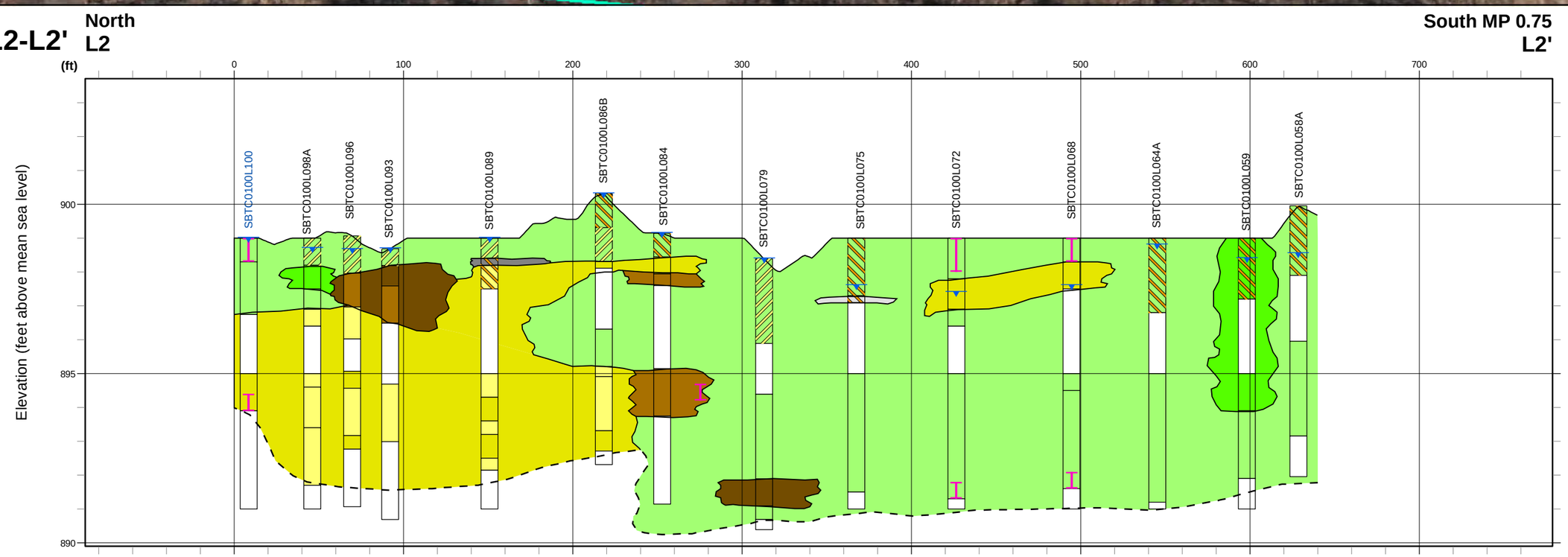
ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_02_Reach_3_Geology_XS_L1_Sheet_5.mxd

Aerial Photography Date: April 2011

Cross Section L2-L2'

Vertical Exaggeration: 20x



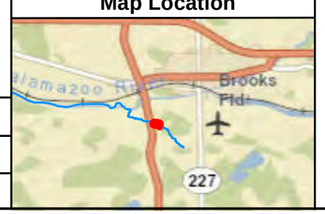
USCS

- No Recovery
- Clay
- Silt
- Silt Subclass
- Gravel
- Peat
- Organic
- Sand
- Sand Subclass

ENBRIDGE

Drawn:	NS	9/22/2014
Approved:	PL	9/22/2014
Project #:	60313732	

Map Location



Overview Legend

- Cross Section L2-L2'
- Cores
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments

Cross Section Legend

- Sample Interval
- Water Level

Observations

- Oil Under Visible Light
- Sheen Under Visible Light
- Fluoresced Oil
- Trace Fluorescence

SBTC0000R000 **Temporary Well Location**

Note: Soil borings with no water levels shown are due to no water present in bore hole.

N

0 20 40 80

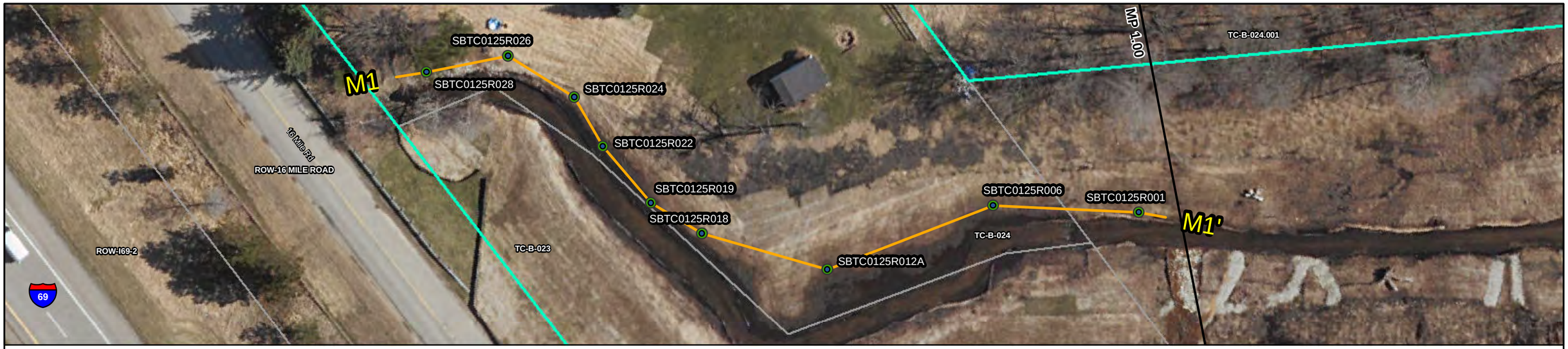
Scale in Feet

FIGURE 2
REACH 3
GEOLOGIC CROSS SECTION L2-L2'
SHEET 6 OF 8

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

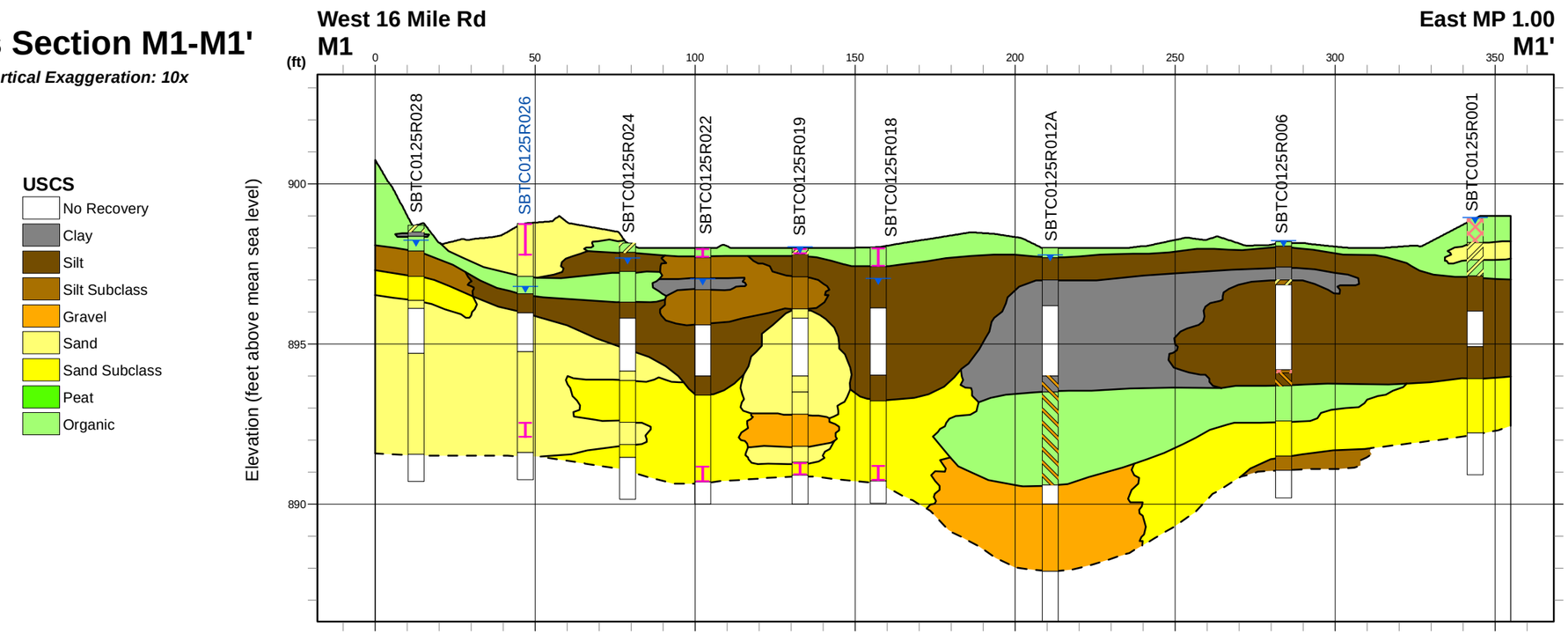
Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_02_Reach_3_Geology_XS_L2_Sheet_6.mxd

Aerial Photography Date: April 2011



Cross Section M1-M1'

Vertical Exaggeration: 10x



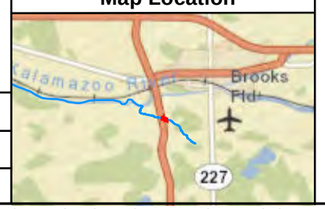
USCS

- No Recovery
- Clay
- Silt
- Silt Subclass
- Gravel
- Sand
- Sand Subclass
- Peat
- Organic

ENBRIDGE

Drawn:	NS	9/22/2014
Approved:	PL	9/22/2014
Project #:	60313732	

Map Location



Overview Legend

- **Cross Section M1-M1'**
- **Cores**
- Reach 3 Spill Area
- Parcel
- **Quarter Mile Grid Segments**

Cross Section Legend

- Sample Interval
- Water Level

Observations

- Oil Under Visible Light
- Sheen Under Visible Light
- Fluoresced Oil
- Trace Fluorescence

SBTC0000R000 **Temporary Well Location**

Note: Soil borings with no water levels shown are due to no water present in bore hole.

N

0 20 40 80

Scale in Feet

FIGURE 2
REACH 3
GEOLOGIC CROSS SECTION M1-M1'
SHEET 7 OF 8

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_02_Reach_3_Geology_XS_M1_Sheet_7.mxd

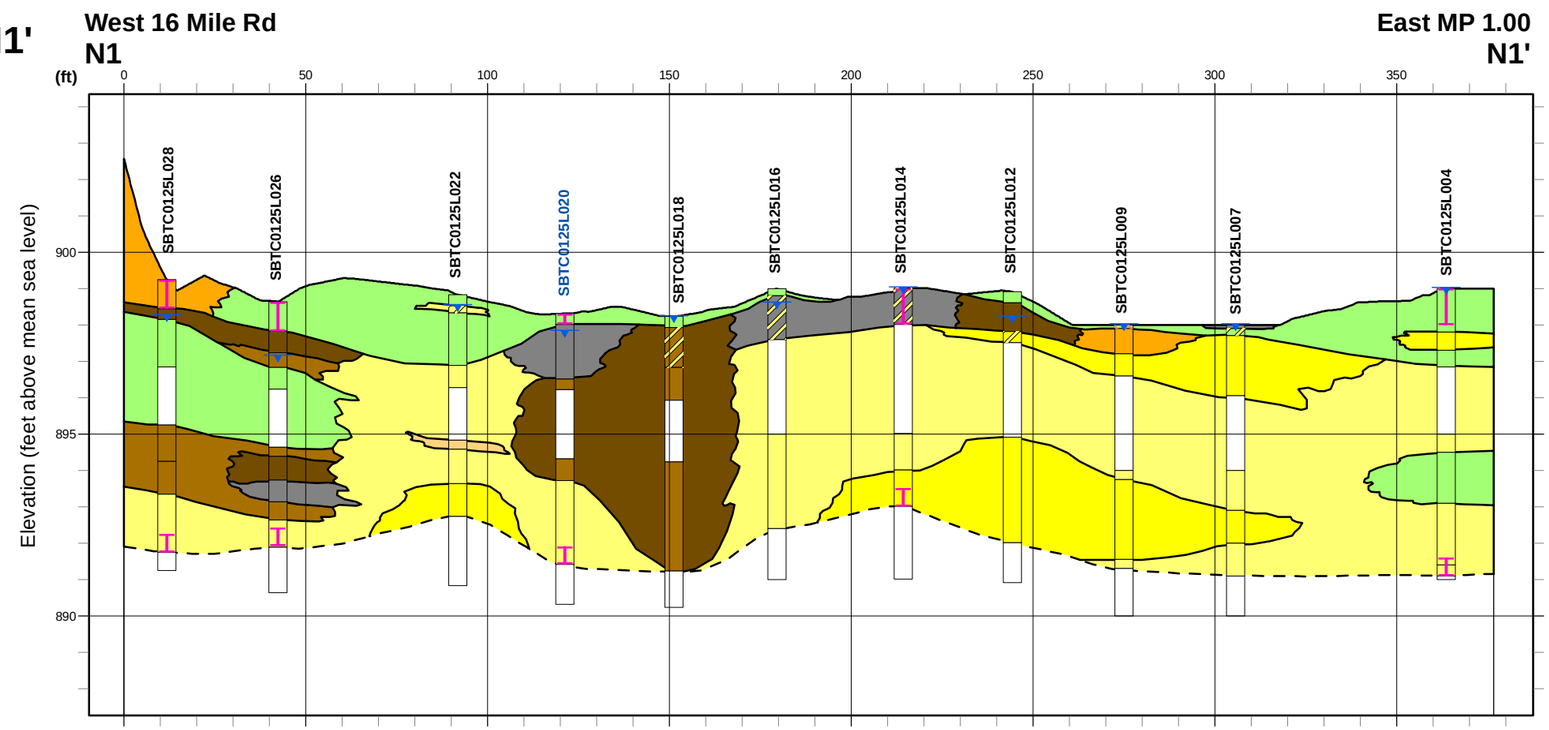
Aerial Photography Date: April 2011

Cross Section N1-N1'

Vertical Exaggeration: 10x

USCS

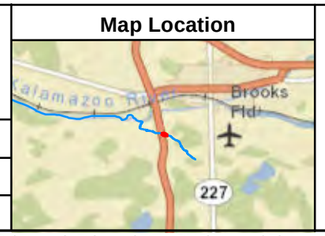
- No Recovery
- Clay
- Silt
- Silt Subclass
- Sand
- Sand Subclass
- Gravel
- Gravel Subclass
- Peat
- Organic



ENBRIDGE

Drawn:	NS	9/22/2014
Approved:	PL	9/22/2014
Project #:	60313732	

Map Location



Overview Legend

- Cross Section N1-N1'
- Cores
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments

Cross Section Legend

- Sample Interval
- Water Level

Observations

- Oil Under Visible Light
- Sheen Under Visible Light
- Fluoresced Oil
- Trace Fluorescence

SBTC0000R000 Temporary Well Location

Note: Soil borings with no water levels shown are due to no water present in bore hole.

N

0 20 40 80

Scale in Feet

FIGURE 2
REACH 3
GEOLOGIC CROSS SECTION N1-N1'
SHEET 8 OF 8

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

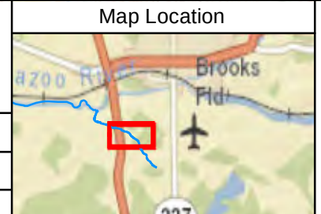
Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_02_Reach_3_Geology_XS_N1_Sheet_8.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	9/3/2014
Approved:	PL	9/3/2014
Project #:	60313732	

Map Location



Legend

- Potable Well
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline

N

0 150 300 600

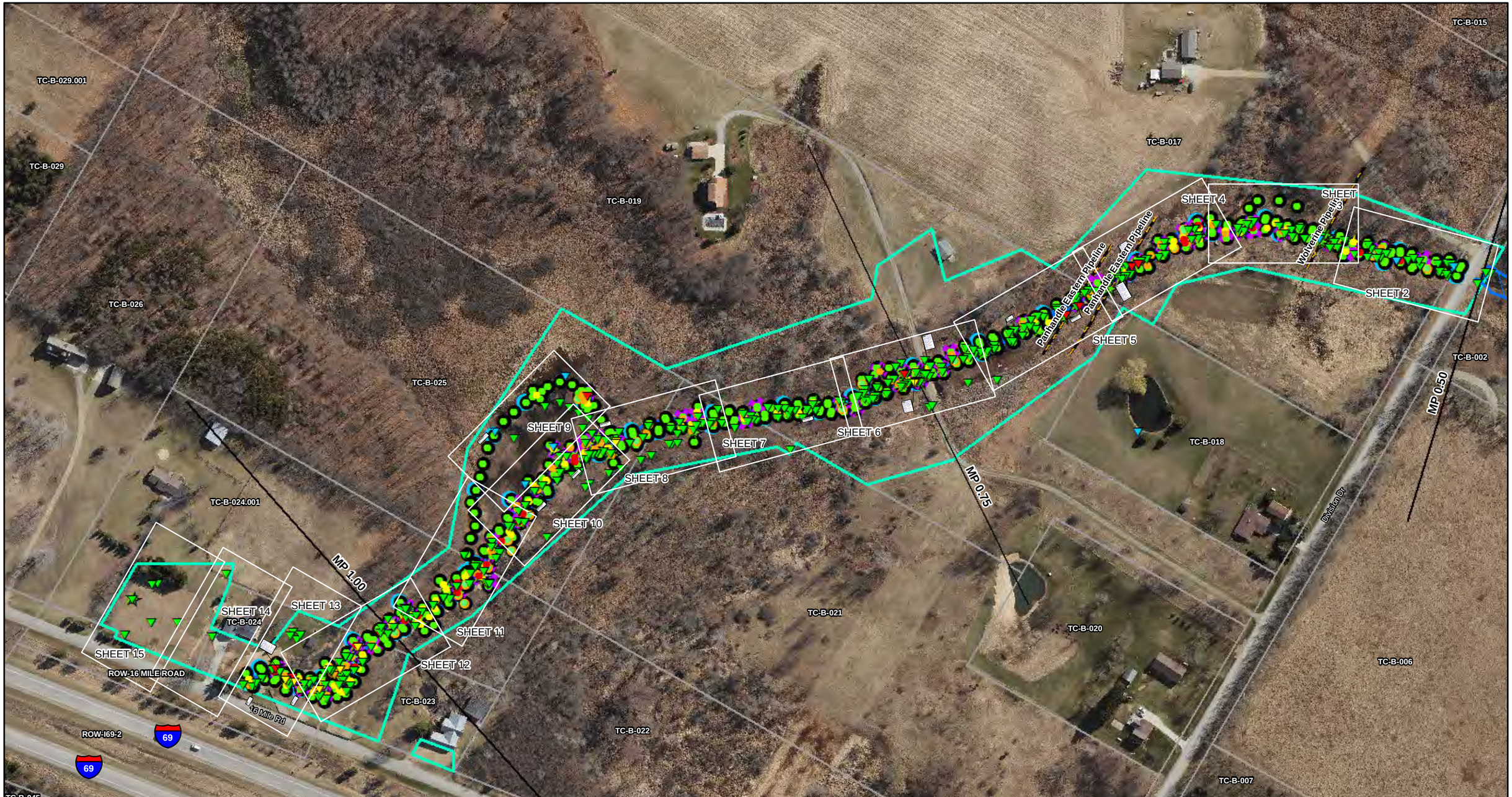
Scale in Feet

FIGURE 3
REACH 3
POTABLE WELL LOCATIONS

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_03_Reach_3_Potable_Wells.mxd

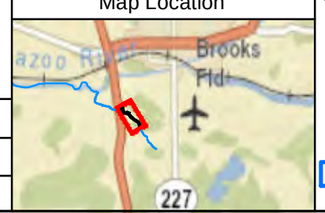
Aerial Photography Date: April 2011



ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location



TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

N

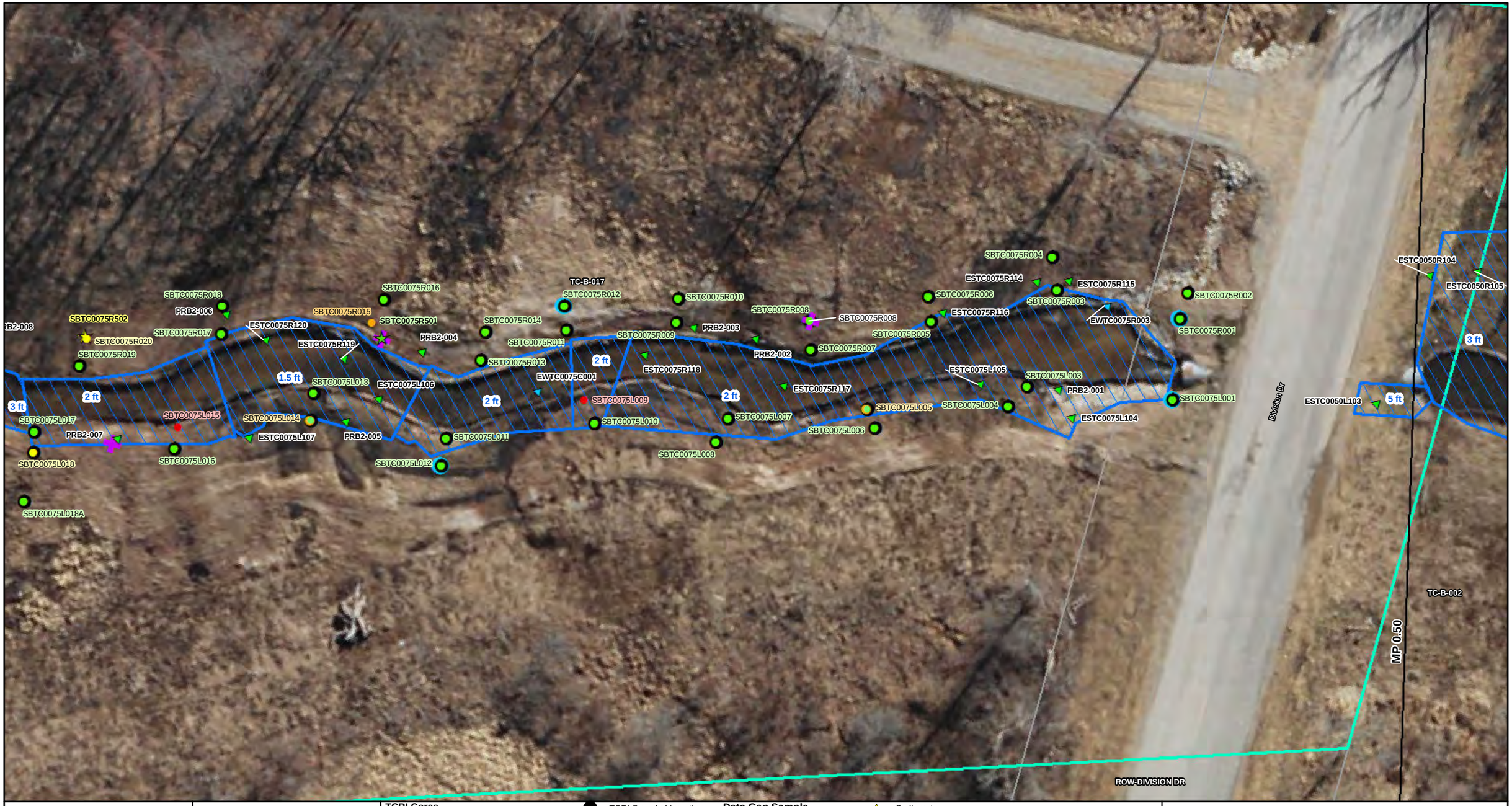
0 95 190 380
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 1 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet1.mxd

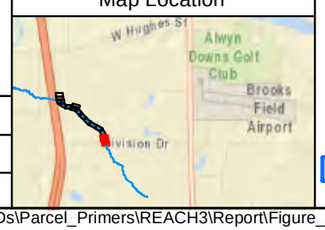
Aerial Photography Date: April 2011



ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location



TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

N

0 10 20 40
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 2 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

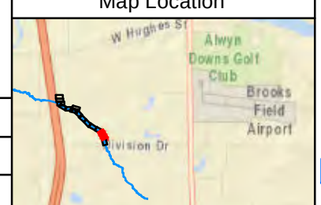
Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet2-15.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location



TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

0 10 20 40
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 3 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet2-15.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location

TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

N

0 10 20 40
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 4 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

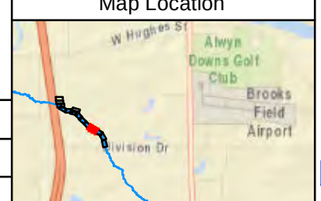
Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet2-15.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location



TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

N

0 10 20 40
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 5 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

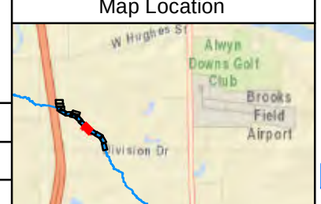
Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet2-15.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location



TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

N

0 10 20 40
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 6 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet2-15.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location

TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

0 10 20 40
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 7 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet2-15.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location

TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

N

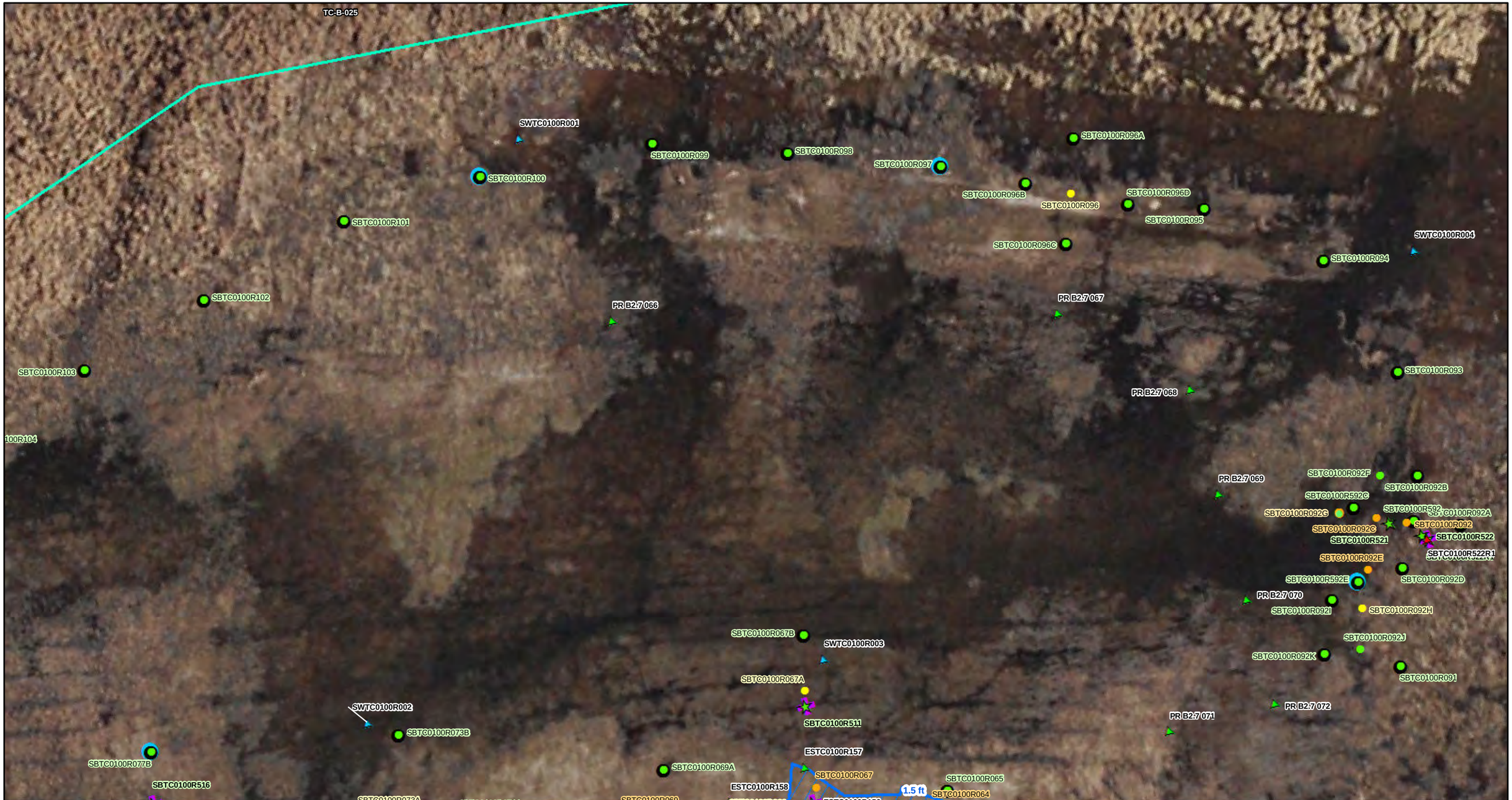
0 10 20 40
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 8 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet2-15.mxd

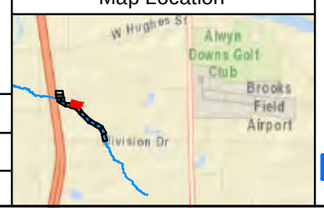
Aerial Photography Date: April 2011



ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location



TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

N

0 10 20 40
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 9 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

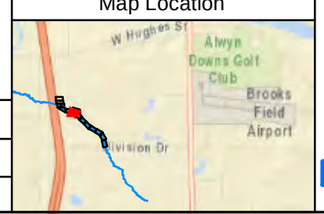
Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet2-15.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location



TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

N

0 10 20 40
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 10 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

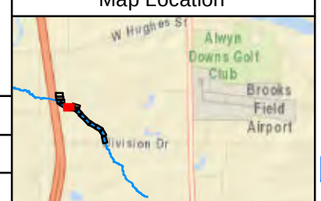
Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet2-15.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location



TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

N

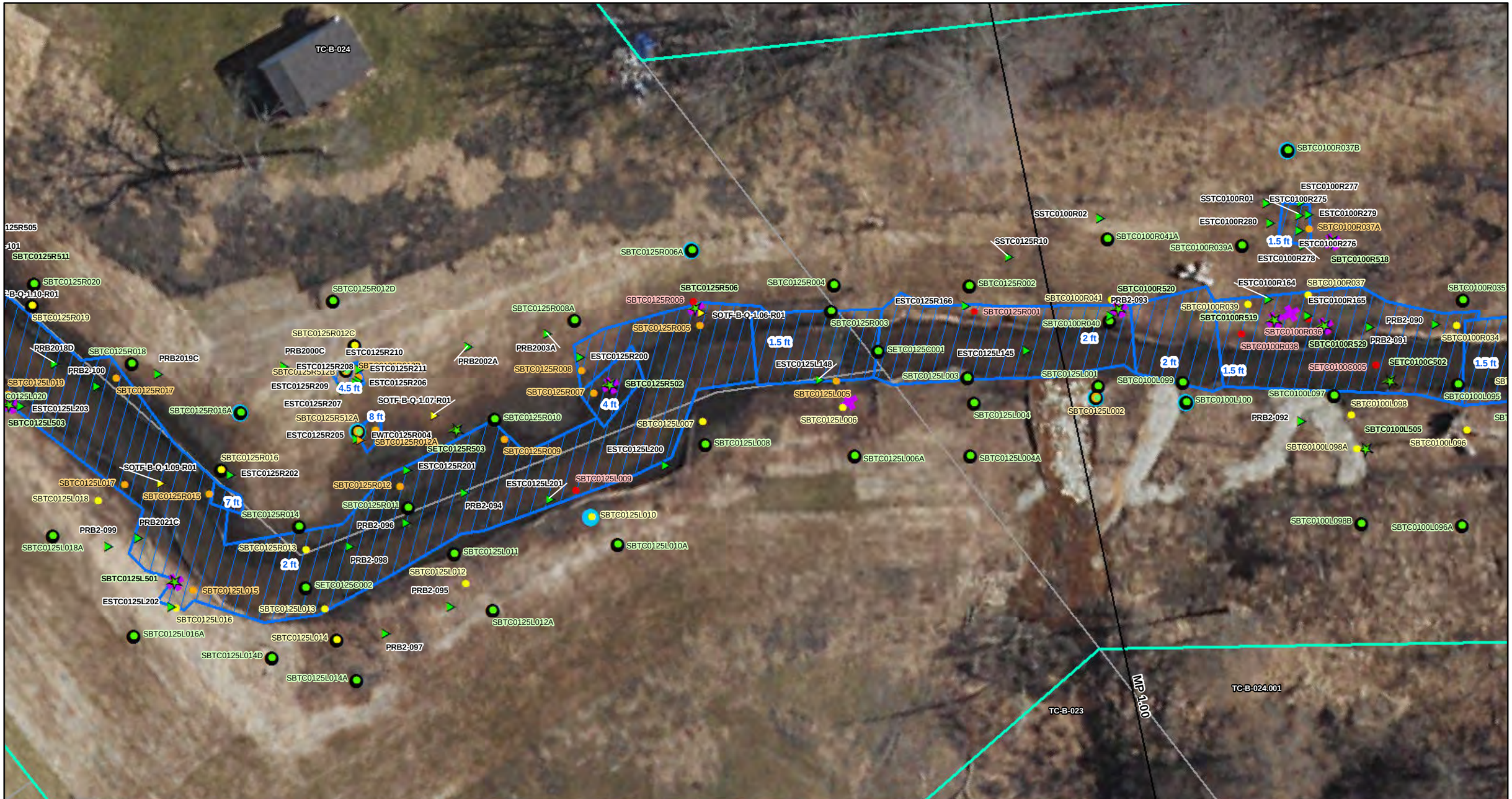
0 10 20 40
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 11 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet2-15.mxd

Aerial Photography Date: April 2011



ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location

TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

N

0 10 20 40
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 12 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet2-15.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location

TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

N

0 10 20 40
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 13 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

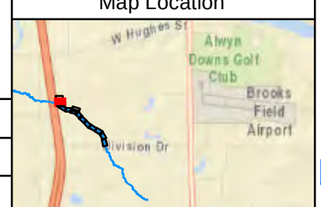
Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet2-15.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location



TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

N

0 10 20 40
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 14 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet2-15.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location

TCRI Cores
- Impact Under Visible Light
- Fluoresence Observed Under UV Light
- Trace Fluoresence Under UV Light
- Surficial Impact Observed in Field
- No Impacts Observed
- 2011 Talmadge Excavation Areas

- TCRI Sampled Location
- TCRI GW Sample
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline
- 2 ft Excavation Depth

Data Gap Sample
- Oil
- Visible Sheen
- Fluoresced Oil
- Trace Fluorescence
- No Oil Observed
- Data Gap Temporary Well

- Sediment
- Soil Boring
- Surface Water
- Surface Soil
- Other Sample

SETC0200C008 Sample Location With Analytical Exceedance

ug/kg - Microgram Per Kilogram
UV - Ultraviolet

N

0 10 20 40
Scale in Feet

FIGURE 4
REACH 3
ALL SAMPLING LOCATIONS
SHEET 15 OF 15

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

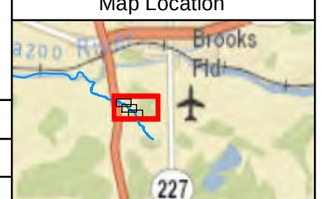
Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_04_Reach_3_All_Samples_Exceedances_Sheet2-15.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	9/18/2014
Approved:	PL	9/18/2014
Project #:	60313732	

Map Location



Legend

2011 SORT Reassessment

- No Oil
- Pooled Oil
- Film (Sheen) Observations
- Remaining Observations
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline

N

0 150 300 600

Scale in Feet

FIGURE 5
REACH 3
SPRING 2011 SORT REASSESSMENT
SHEET 1 OF 4

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

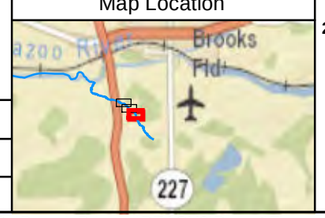
Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_05_Reach_3_SORT_Sheet1.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	9/18/2014
Approved:	PL	9/18/2014
Project #:	60313732	

Map Location



Legend

2011 SORT Reassessment

- No Oil
- Pooled Oil
- Film (Sheen) Observations
- Remaining Observations
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline

N

0 50 100 200

Scale in Feet

FIGURE 5
REACH 3
SPRING 2011 SORT REASSESSMENT
SHEET 2 OF 4

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

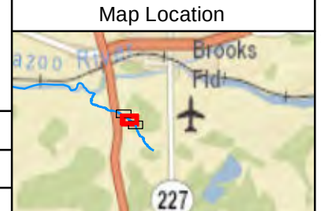
Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_05_Reach_3_SORT_Sheet2-4.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	9/18/2014
Approved:	PL	9/18/2014
Project #:	60313732	

Map Location



Legend

2011 SORT Reassessment

- No Oil
- Pooled Oil
- Film (Sheen) Observations
- Remaining Observations
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline

N

0 50 100 200

Scale in Feet

FIGURE 5
REACH 3
SPRING 2011 SORT REASSESSMENT
SHEET 3 OF 4

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

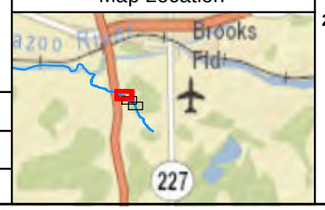
Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_05_Reach_3_SORT_Sheet2-4.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	9/18/2014
Approved:	PL	9/18/2014
Project #:	60313732	

Map Location



Legend

2011 SORT Reassessment

- No Oil
- Pooled Oil
- Film (Sheen) Observations
- Remaining Observations
- Reach 3 Spill Area
- Parcel
- Quarter Mile Grid Segments
- Pipeline

N

0 50 100 200

Scale in Feet

FIGURE 5
REACH 3
SPRING 2011 SORT REASSESSMENT
SHEET 4 OF 4

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

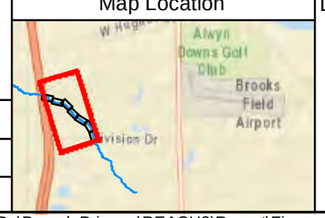
Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_05_Reach_3_SORT_Sheet2-4.mxd

Aerial Photography Date: April 2011

ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location



Legend

2010 U.S. EPA Clearance Areas

A - Excavated to Visual Extent
B - Excavated to Water
C - Excavated to Confining Layer
Special - Does not Meet A, B, or C Criteria

2010 Post-Excavation Assessment Soil Sample

2010 Mat Road Soil Sample

2011-2012 Excavation

Reach 3 Spill Area

Parcel

Quarter Mile Grid Segments

Pipeline

SETC0200C008 Sample Location With Analytical Exceedance

N

0 100 200 400

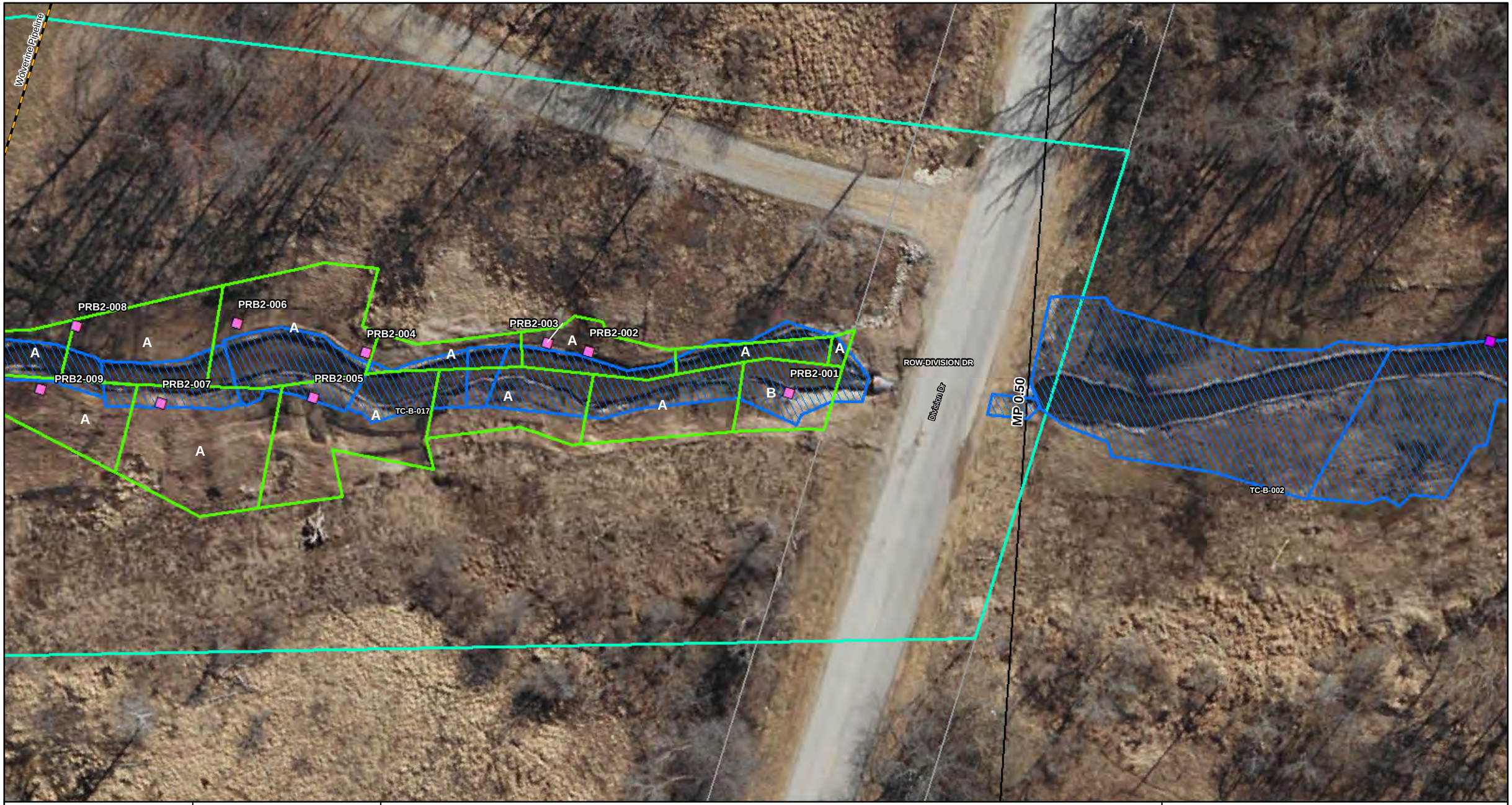
Scale in Feet

FIGURE 6
REACH 3
2010 U.S. EPA CLEARANCE AREAS AND
2010 POST-EXCAVATION ASSESSMENT SOIL SAMPLES
SHEET 1 OF 8

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_06_Reach_3_EPA_Clearance_Areas_Sheet1.mxd

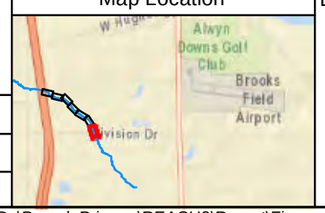
Aerial Photography Date: April 2011



ENBRIDGE

Drawn:	NS	10/2/2014
Approved:	PL	10/2/2014
Project #:	60313732	

Map Location



Legend

2010 U.S. EPA Clearance Areas

A - Excavated to Visual Extent
B - Excavated to Water
C - Excavated to Confining Layer
Special - Does not Meet A, B, or C Criteria

2010 Post-Excavation Assessment Soil Sample

2010 Mat Road Soil Sample

2011-2012 Excavation

Reach 3 Spill Area

Parcel

Quarter Mile Grid Segments

Pipeline

SETC0200C008 Sample Location With Analytical Exceedance

N

0 15 30 60

Scale in Feet

FIGURE 6
REACH 3
2010 U.S. EPA CLEARANCE AREAS AND
2010 POST-EXCAVATION ASSESSMENT SOIL SAMPLES
SHEET 2 OF 8

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Z:\Work\GIS\Kalamazoo_River_RI\MXDs\Parcel_Primers\REACH3\Report\Figure_06_Reach_3_EPA_Clearance_Areas_Sheet2-7.mxd

Aerial Photography Date: April 2011